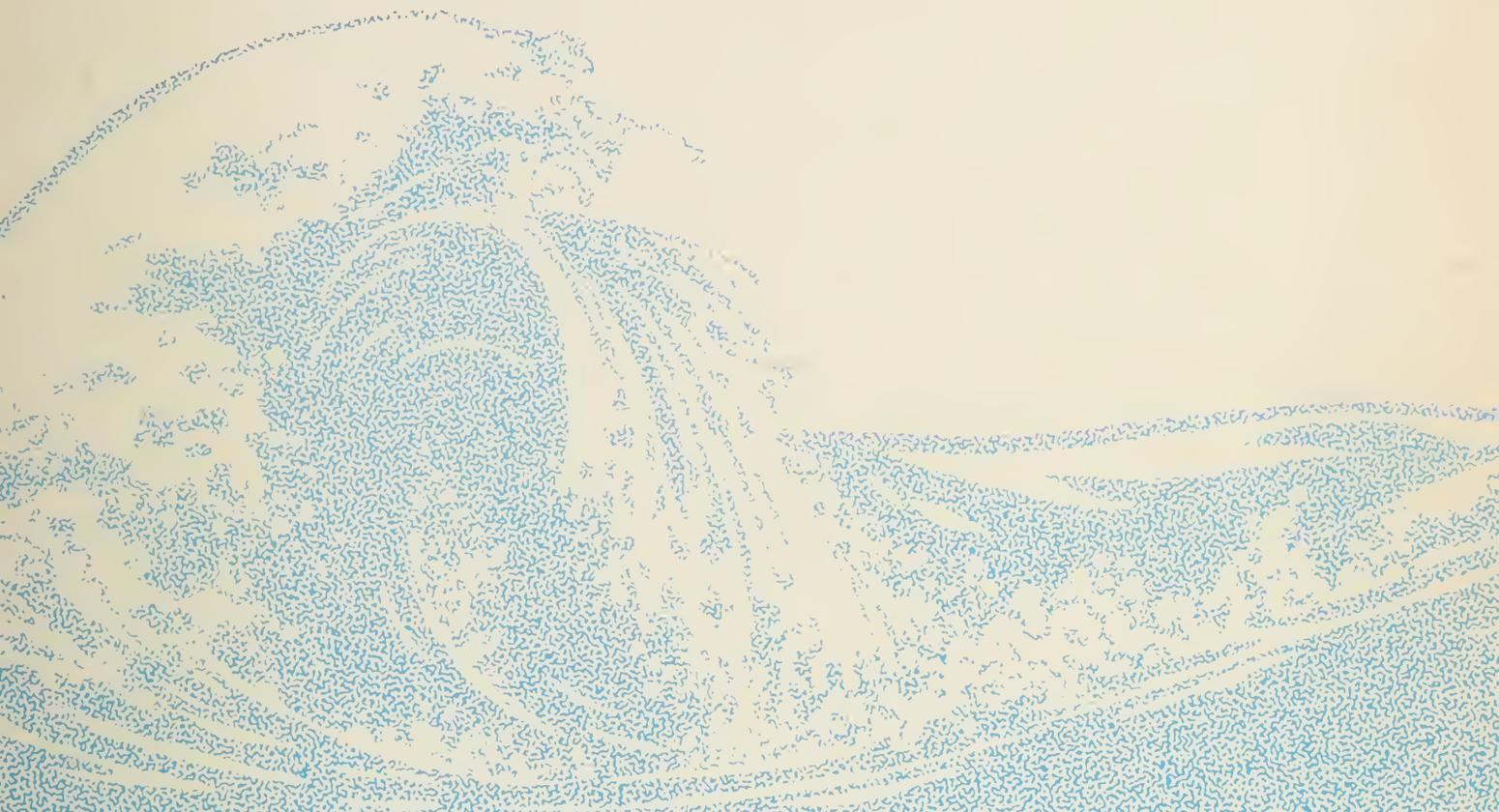
# CATALOG 1978-1979



## NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIFORNIA

## MISSION

To conduct and direct the advanced education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the naval service; and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence.

# CALENDAR FOR 1978-79 ACADEMIC YEAR

## 1978

Refresher Course begins ..... Monday, 14 August
Labor Day (holiday) ..... Monday, 4 September
Registration ..... Monday, 25 September
Examination Week for Summer Quarter ..... 25-28 September
Summer Quarter ends ..... Thursday, 28 September
Graduation ..... Friday, 29 September
Fall Quarter begins ..... Monday, 2 October
Columbus Day (holiday) ..... Monday, 9 October
Veterans Day (holiday) ..... Friday, 10 November
Thanksgiving Day (holiday) ..... Thursday, 23 November
Examination Week for Fall Quarter ..... 15-19 December
Fall Quarter ends ..... Tuesday, 19 December
Graduation ..... Tuesday, 19 December

## 1979

Registration ..... Tuesday, 2 January
Winter Quarter begins ..... Monday, 8 January
Refresher Course begins ..... Monday, 12 February
Washington's Birthday (holiday) ..... Monday, 19 February
Registration ..... Monday, 26 March
Examination Week for Winter Quarter ..... 26-29 March
Winter Quarter ends ..... Friday, 30 March
Graduation ..... Friday, 30 March
Spring Quarter begins ..... Monday, 2 April
Memorial Day (holiday) ..... Monday, 28 May
Examination Week for Spring Quarter ..... 18-21 June
Spring Quarter ends ..... Friday, 22 June
Graduation ..... Friday, 22 June
Registration ..... Monday, 2 July
Fourth of July (holiday) ..... Wednesday, 4 July
Summer Quarter begins ..... Monday, 9 July
Refresher Course begins ..... Monday, 13 August
Labor Day (holiday) ..... Monday, 3 September
Registration ..... Monday, 24 September
Examination Week for Summer Quarter ..... 24-27 September
Summer Quarter ends ..... Friday, 28 September
Graduation ..... Friday, 28 September
Fall Quarter begins ..... Monday, 1 October
Columbus Day (holiday) ..... Monday, 8 October
Veterans Day (holiday) ..... Monday, 12 November
Thanksgiving Day (holiday) ..... Thursday, 22 November
Examination Week for Fall Quarter ..... 15-19 December
Fall Quarter ends ..... Wednesday, 19 December
Graduation ..... Wednesday, 19 December
Registration ..... Monday, 31 December
Winter Quarter begins ..... Monday, 7 January 1980

Superintendent

TYLER FREELAND DEDMAN
B.S., U. S. Naval Academy, 1947
M.S. in Engineering, Princeton University, 1957

Academic Dean

JACK RAYMOND BORSTING
B.A., Oregon State University, 1951;
M.A., University of Oregon, 1952; Ph.D., 1959

## BOARD OF ADVISORS

The NPS Board of Advisors is a distinguished group of civilian educators, business and professional men. The Board visits the campus periodically to examine educational programs, recommend improvements and discuss plans and problems with the Superintendent. Present members are:

Rear Admiral William A. Brockett, USN (Ret), Past President, Webb Institute of Naval Architecture

Dr. Kermit O. Hanson, Dean, School and Graduate School of Business Administration, University of Washington

Dr. Gerald J. Lieberman, Vice Provost and Dean of Research, Stanford University

Dr. Hans M. Mark, Under Secretary of the Air Force

Admiral Frederick H. Michaelis, USN, Chief of Naval Material, Navy Department

Dr. Russell R. O'Neill, Dean, School of Engineering and Applied Sciences, University of California, Los Angeles

Dr. David S. Potter, Vice President, Environmental Activities Staff, General Motors Corporation

Admiral James S. Russell, USN (Ret) (Board of Chairman), Consultant, Boeing Aircraft

The Honorable Bob Wilson, House of Representatives, Washington, DC

## SUPERINTENDENT'S STAFF

DIRECTOR OF PROGRAMS, JOSEPH MICHAEL BARRON, Captain, U.S. Navy; B.S., Naval Postgraduate School, 1962; M.S., George Washington Univ., 1972.

DIRECTOR OF MILITARY OPERATIONS AND LOGISTICS, DEMPSEY BUTLER, JR., Captain, U.S. Navy; B.S., U.S. Naval Academy, 1949; B.S., Naval Postgraduate School, 1963; M.S. in Aeroelectronics, 1964.

DEAN OF EDUCATIONAL DEVELOPMENT and EXECUTIVE DIRECTOR, OFFICE OF CONTINUING EDUCATION, WALTER MAX WOODS: B.S., Kansas State Teachers College, 1951; M.S., Univ. of Oregon, 1957; Ph.D., Stanford Univ., 1961.

DEAN OF RESEARCH AND DEAN OF SCIENCE AND ENGINEERING, WILLIAM MARSHALL TOLLES; B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California at Berkeley, 1962.

DEAN OF ACADEMIC PLANNING and DEAN OF INFORMATION AND POLICY SCIENCES, DAVID ALAN SCHRADY: B.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965.

DEAN OF ACADEMIC ADMINISTRATION, ARABHAM SHEINGOLD; B.S., College of the City of New York, 1936; M.S., 1937.

REGISTRAR, EDITH JEAN WARRINER; B.A., Occidental College, 1947.

## HISTORY

The Naval Postgraduate School is in its 70th year of operation. The development of a naval institution of higher learning dedicated to the advanced education of commissioned officers began on 9 June 1909 when the Postgraduate Department of the U. S. Naval Academy was established at Annapolis. Ten officers made up the first class, three professors formed the faculty, and marine engineering was the one course of study.

The School closed during World War I, but classes resumed in 1919. In ensuing years, the School grew in size and scope as its educational offerings were more comprehensively directed towards the broad military applications of science and technology. The postgraduate department was renamed the United States Naval Postgraduate School, but still operated as a part of the Naval Academy. In 1927, the General Line Course was established to acquaint junior line officers with modern developments within the Navy and to broaden their professional knowledge of future command at sea.

With the advent of World War II, the School's activities increased substantially. There was a large growth in student enrollment and educational programs were expanded to meet the evolving needs of the Navy. Following the end of the War, plans were initiated to move the School to more suitable facilities and to enhance its academic status.

Between 1945 and 1948, Congress established the School as a separate activity under its own Superintendent, created the office of Academic Dean and granted the Superintendent the authority to award the bachelor's, master's and doctor's degrees. It also approved Monterey as the future home of the School. The General Line School, closed during the war years, was re-established at Monterey and at Newport, Rhode Island.

After purchasing the former Del Monte Hotel and surrounding acreage, the Navy officially established the School on the West Coast on 22 December 1951. With its enlarged facilities, the School continued to grow in curricular programs and in student enrollment. In 1956, the Navy Management School was formed as a component of the Postgraduate School to provide graduate education in the theory and application of scientific methods of management. In 1958, the General Line School was renamed the General Line and Naval Science School, and a Bachelor of Science curriculum was offered to selected officers who had not completed their undergraduate education. A further need for baccalaureate courses resulted in the inauguration of the Bachelor of Arts curriculum in 1961.

A major internal reorganization of the School was authorized in 1962. The Management, Engineering, and General Line School merged, making the Naval Postgraduate School, in effect, a naval university, unified in policies, procedures and objectives.

In 1973, the Naval Postgraduate School, together with the Naval War College and the U. S. Naval Academy, was made a component of the Naval Education and Training Command located at Pensacola, Florida.

Since 1946, the School has awarded 6,047 bachelor's degrees, 8,229 master's degrees, 255 engi-

neer's degrees, and 91 doctorate degrees. At the present time, the total educational emphasis is on graduate-level programs.

Currently, the Naval Postgraduate School occupies a multi-million dollar campus, graduates an average of 800 students a year and offers a range of curricular programs specifically tailored to impart the scientific, engineering, operational and administrative knowledge required to meet the present and projected professional needs of the Department of Defense. Its student body includes officers of all five U. S. services and 25 allied services. Also, since 1975, it has enrolled civilian employees of the U. S. Government.

## ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a rear admiral of the line of the Navy. His principal assistants are a Provost/Academic Dean who is the senior member of the civilian faculty; and two captains of the line — a Director of Programs, and a Director of Military Operations and Logistics.

The academic programs and direct supporting functions are administered and operated through a unique organization composed of Curricular Offices and Academic Departments. The former are staffed by naval officers and civilian faculty members whose primary functions are threefold: (1) academic counseling and military supervision of officer students; (2) curriculum development and management to insure attainment of professional and academic objectives; and (3) liaison with curricular sponsor representatives. Officer students in each curricula group pursue similar or closely related curricula.

Officer students are grouped into the following curricular program areas:

- Administrative Science
- Aeronautical Engineering
- Command, Control and Communications (C3)
- Computer Technology
- Electronics and Communications
- Environmental Sciences
- Naval Engineering
- Naval Intelligence/National Security Affairs
- Operations Research/Systems Analysis
- Weapons Engineering/ASW

The teaching functions of classroom and laboratory instruction and thesis supervision are accomplished by a faculty which is organized into eleven academic departments and three interdisciplinary groups:

- Administrative Sciences
- Aeronautics
- ASW Group
- Command, Control and Communications (C3) Group
- Computer Science
- Electrical Engineering
- Electronic Warfare Group
- Mathematics
- Mechanical Engineering
- Meteorology
- National Security Affairs
- Oceanography
- Operations Research
- Physics and Chemistry

Over five-sixths of the teaching staff are civilians of varying professional rank and the remainder military officers.

The Academic Program organization described is supervised by the Director of Programs, the Dean of Information and Policy Sciences,

and the Dean of Science and Engineering who collaborate to share jointly the responsibilities for planning, conduct and administration of the several educational programs.

The close tie between elements of this dual organization is further typified by the role of the Academic Associates. These are individual civilian faculty members appointed by the Academic Dean to work closely with the Curricular Officers in the development and continuing monitoring of curricula — the Navy's needs being the responsibility of the Curricular Officer, and academic soundness being the responsibility of the Academic Associate.

Logistic service support is rendered by conventional departments such as Supply and Public Works grouped organizationally under a Director of Military Operations and Logistics. Certain other officers such as the Comptroller and Civilian Personnel Officer are directly responsible to the Superintendent in a slightly modified but typical naval staff organization.

## FACILITIES

The Naval Postgraduate School is located within the City of Monterey, and only a mile east of the downtown business area and the city's Fishermen's Wharf. The site of the School is the former luxury Del Monte Hotel of pre-World War II days. The beautifully landscaped campus contains most of the academic and administration buildings within the main grounds. There is an adjacent beach area for research and a nearby laboratory and recreation area. The total campus covers approximately 600 acres.

The Superintendent and central administrative officers, along with other service functions, are located in Herrmann Hall, the most prominent building on the campus because of its Spanish architecture.

Most of the academic classrooms, laboratories and offices are located in Spanagel, Bullard, Halligan, Root and Ingersoll Halls. The newest building is the Dudley Knox Library which was completed early in 1972. Adjacent to the main academic buildings is King Hall, a large lecture hall used to seat the student body, faculty, and staff when occasions require.

## STUDENT AND DEPENDENT INFORMATION

Monterey Peninsula and the cities of Monterey, Carmel, Pacific Grove, and Seaside, all within 5 miles of the School, provide community support for the students of the Postgraduate School.

LaMesa Village, located 3 miles from the School, consists of former Wherry Housing, Capehart Housing and Townhouses. There are a total of 877 units of public quarters for officer students. An elementary school is located within the housing area. Limited housing for single students is available in the BOQ located on the main campus in Herrmann Hall.

Student services include a campus branch of Bank of America, Navy-Federal Credit Union, U.S. Post Office, Student Mail Center, Navy Exchange and a child care center. A large commissary is located at Fort Ord and is available to Navy personnel.

Medical facilities include a Dispensary, supported by the U.S. Army

Hospital at Fort Ord (7 miles away), and the U.S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located in Herrmann Hall.

The center of campus social activity is the Commissioned Officers and Faculty Club, located in the old hotel building. There are many beautifully appointed rooms, just as they were at the turn of the century, including a ballroom and Open Mess. Two beautiful chapels are located on the main campus.

Student wives and wives of allied officers are active in the Officer Student Wives Club, the International Wives Club, as well as a Little Theater group which puts on three productions a year.

Recreational facilities include a swimming pool, an 18-hole golf course, putting green, tennis courts, ping pong and badminton courts, basketball and volley ball courts, a softball diamond, picnic grounds, bowling lanes, driving range, archery range, and gymnasium. Other organized recreational activities are provided by the Ladies Golf Association, Mens Golf Association, Soccer Club, Rugby Club, Lacross Club, Ski Club, Karate Club, Tennis Club, and basketball and softball teams. The School also has a very active Military Amateur Radio Station and a Navy Flying Club.

Personnel assigned to the Postgraduate School have an active Sailing Association open to sponsors and their dependents as well as members of the faculty. Sailing conditions are among the finest on the West Coast with excellent weather prevailing from February through November. The School's recreation department schedules the 3 Shields Class Racing Sloops, 2 Santana-22s, 2 Columbia 22s, and 1 forty-foot launch on a first-come first-served basis. Classes for beginners and advanced sailing enthusiasts are conducted twice a year, following the January and July inputs. The School works closely with civilian yacht clubs to coordinate many sailing events throughout the year and, in addition, hosts the annual Navy West Coast Match racing championships.

## TEXTBOOKS

The Naval Postgraduate School operates a bookstore under the Navy Exchange system. It stocks all required textbooks and related school supplies. Students can purchase their books either from the school or local bookstores, or from other students.

## ADMISSIONS PROCEDURES

### U.S. NAVAL OFFICERS

U. S. Navy officers interested in admission to one of the curricula offered at the Postgraduate School are referred to OPNAV Notice 1520, Subject: Postgraduate Educational Programs, which is published annually by the Chief of Naval Operations. This directive outlines the various educational programs available and indicates the method of submitting requests for consideration for each program.

A selection board is convened annually by the Chief of Naval Personnel to select officers, based upon professional performance, academic background, and ability, within quotas which reflect the Navy's requirements in the various fields of study available. Officers will be notified of selection by official corre-

spondence at the earliest feasible date after the meeting of the selection board.

An officer's chances for selection will be enhanced if he has completed recommended preparatory courses for the graduate-education program of his choice. Appropriate courses for individual self-study are available from the Naval Postgraduate School Continuing Education Program, described in a following section of this catalog.

### OTHER U.S. MILITARY OFFICERS

Officers on duty with other branches of service are eligible to attend the Postgraduate School. They should apply in accordance with the directives promulgated by the Department of the Army, Department of the Air Force, Commandant U.S. Marine Corps, or the Commandant U.S. Coast Guard, as appropriate.

### ALLIED COUNTRY MILITARY OFFICERS

Military officers from Allied countries may be admitted to most curricula. Their admission is subject to availability of quotas assigned to each country. The procedures for application are contained in OPNAV INSTRUCTION 4950.1E. Correspondence must be processed through normal channels; requests from individual officers should not be sent directly to the Naval Postgraduate School. In addition to fluency in English, candidates must satisfy the academic standards for each curriculum as described in this catalog.

### CIVILIAN EMPLOYEES OF U.S. GOVERNMENT

Civilian employees of the United States federal government may be admitted for study upon request and sponsorship by a federal activity. They do not need to pursue the curricula designed for officer students as described in this catalog but instead will determine the combination and sequence of courses that will best meet their educational needs.

Requests for admission should be in letter form, indicating the academic area of interest and degree intentions, and enclosing official transcripts of all previous college work. GRE and/or GMAT test scores are not required but will be considered when included in the submission.

Requests for admission or questions regarding admission procedures should be directed to the Dean of Academic Administration, Code 014, Naval Postgraduate School, Monterey, CA 93940; or telephone (408) 646-2392 or Autovon 878-2392.

## TRANSFER OF CREDITS

Upon entry to the Naval Postgraduate School, each student's academic record will be evaluated for possible transfer of credit or for exemption from portions of the curricular program by validation of course work previous completed. Students may also utilize knowledge gained through self-study, experience or service-related education to seek validation or credit for curriculuar courses by taking a departmental examination.

Certain graduate-level courses previously completed may be accepted for transfer credit. These include graduate-level courses taken after completion of the baccalaureate degree and those taken in the last

term before award of the baccalaureate and certified to be in excess of degree requirements.

As a consequence of its policy on transfer of credit, the School requires only 12 quarter hours in residency for the master's degree. Questions on transfer credit may be directed to the Dean of Academic Administration by letter or AUTOVON 878-2391.

## DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's, Engineer's or Doctor's degrees in engineering or related fields upon qualified graduates of the School. This authority is subject to such regulations as the Secretary of the Navy may prescribe, contingent upon due accreditation from time to time by the appropriate professional authority of the applicable curricula. Recipients of such degrees must be found qualified by the Academic Council in accordance with prescribed academic standards.

The Naval Postgraduate School was accredited in 1962 as a full member of the Western Association of Schools and Colleges. Initial accreditation as an associate member was given in 1955. Specific engineering curricula have been accredited by the Engineers' Council for Professional Development (ECPD) since 1949.

The Postgraduate School operates under a quarter system, with each term of instruction lasting 12 weeks. The last week of each quarter is set aside for examinations. In addition, there are two 2-week recesses during the academic year, one over Christmas and one during June-July.

Students' performance is evaluated on the basis of a quality point number assigned to the letter grade achieved in a course as follows:

| *Performance* | *Grade* | *Point Value* |
|---|---|---|
| Excellent | A | 4 |
| | A– | 3.7 |
| | B+ | 3.3 |
| | B | 3 |
| | B– | 2.7 |
| | C+ | 2.3 |
| | C | 2 |
| | C– | 1.7 |
| | D+ | 1.3 |
| | D | 1 |
| Failing | X | 0 |
| Incomplete | I | – |
| Withdrew Passing | W | – |
| Withdrew Failing | WX | 0 |
| Nongraded | N | – |
| Pass | P | – |
| Fail | F | – |

Courses may be designated for P and F grading when approved by the Academic Department and the Academic Council. Hours earned by the grade of P shall be counted toward fulfilling course hours specified by the degree requirements.

A grade of Incomplete (I), if not removed within twelve weeks following the end of the term for which it was received, will be replaced by the grade "X." Exceptions must be individually approved by the Academic Council.

When the quarter-hour credit of a course is multiplied by the point value of the student's grade, a quality point value for the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the

quarter-hour credit of all courses gives a weighted numerical evaluation of the student's performance termed the Quality Point Rating (QPR). A student achieving a QPR of 3.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours.

Officer students have no major duties beyond applying themselves diligently to their studies. It is expected that students will maintain a high level of scholarship and develop attributes which are associated with a scholar seeking knowledge and understanding. Program schedules are such that the student should anticipate spending several hours in evening study each weekday to supplement time available for study between classes.

The courses listed in this catalog are assigned a level of academic credit by the numbers assigned.

0001-0999 No credit
1000-1999 Lower division credit
2000-2999 Upper division credit
3000-3999 Upper division or graduate credit
4000-4999 Graduate credit

The two numbers in parenthesis (separated by a hyphen) following the course title indicate the hours of instruction per week in classroom and laboratory respectively. Laboratory hours are assigned half the value shown in calculating quarter hours for the credit value of the course. Thus a (3-2) course (having three hours recitation and two hours laboratory) will be assigned credit value of 4 quarter hours.

## DEGREE REQUIREMENTS

### Certificates of Completion

Certificates of completion are issued to students who complete programs but do not qualify for a degree. To establish eligibility for a Certificate of Completion, a student must normally maintain an overall QPR of 2.0 or better.

### Requirements for the Master of Arts and Master of Science Degrees

1. The Master's Degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Master's Degree are as follows:

   a. 32 quarter hours of graduate level credits of which at least 12 quarter hours must be earned on campus.
   b. A thesis or its equivalent is required. If the thesis be waived, at least 8 quarter hours of approved courses 4000-4999 shall be substituted for it.
   c. Departmental requirements for the degree in a specified subject.

3. Admission to a program leading to the Master's degree requires:

   a. A baccalaureate degree or the equivalent.
   b. Appropriate undergraduate preparation for the curriculum to be pursued. If a student enters the Postgraduate School with inadequate undergraduate preparation, he will be required to complete the undergraduate prerequisites in addition to the degree requirements.
   c. A demonstrated academic potential for completing the curriculum.

4. In order to qualify for a Master's degree, a student first must be admitted to candidacy for the degree. Application for such admission to candidacy shall be made to the Dean of Academic Administration, via the Chairman of the department of the major, subsequent to completion of 50% of a curriculum and prior to completion of 75% of the curriculum.

a. Students having a Total QPR of 3.00 or greater at the time of application automatically will be admitted to candidacy.
b. Students having a Total QPR from 2.50 to 2.99 inclusive, will require approval by the Academic Council upon recommendation of the Chairman of the department of the major for admission to candidacy.
c. Students having a Total QPR below 2.50 will not be admitted to candidacy for a Master's degree.

5. To be eligible for the Master's degree, the student must attain a minimum average quality point rating of 3.00 in all the 4000 and 3000 level courses in his curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

### Requirements for the Degree: Engineer

1. The Engineer degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree.

2. Minimum Postgraduate School requirements for the degree of Engineer are as follows:

a. 72 quarter hours of graduate level courses including at least 30 hours in courses 4000-4999.
b. An acceptable thesis.
c. One academic year in residence.
d. Departmental requirements for the degree in a specified Engineering field.
e. A quality point rating of at least 3.00 in all graduate courses in the curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

### Requirements for the Doctor's Degree

Any program leading to the Doctor of Philosophy or Doctor of Engineering shall require the equivalent of at least three academic years of study beyond the baccalaureate level, with at least one academic year being spent at the School. A requirement for admission is a Bachelor's degree that includes the prerequisites for full graduate status in the department of his major study.

A general outline of a candidate's progress through the program is as follows:

a. Application to the appropriate department chairman for admission and acceptance.
b. Appointment of the student's Doctoral Committee, which bears responsibility for the study program and guidance of the research program.
c. Inclusion of one or more minors in the study program; for the Doctor of Philosophy at least one foreign language. For Doctor of Engineering, demonstrated proficiency in computer programming is required, with no foreign language.

d. When study program is essentially complete, administration of the Qualifying Examination, including both oral and written parts.
e. Admission to candidacy and start of work on Doctoral Dissertation on a subject approved by the Doctoral Committee.
f. Upon completion of dissertation and acceptance by Doctoral Committee, administration of final oral examination.
g. Upon unanimous recommendation of Doctoral Committee, Academic Council makes final decision on recommendation for award of the degree.

## ACADEMIC HONORS

PROFESSIONAL SOCIETIES. Students have the opportunity to attend many professional meetings held at the Naval Postgraduate School. Several local chapters provide for student membership. These include Eta Kappa Nu, Sigma Xi, Tau Beta Pi, as well as ACM (Association for Computing Machinery), AIAA (American Institute of Aeronautics and Astronautics), AMS (American Meterological Society, ASME (American Society of Mechanical Engineers), ASNE (American Society of Naval Engineers), IEEE (Institute of Electrical and Electronics Engineers, Inc.), ORSA (Operations Research Society of America), and the Marine Technology Society.

DEAN'S LIST. Students who distinguish themselves academically are recognized at the end of each quarter by being placed on the Dean's List. This recognition is awarded to students who earn a Quality Point Rating of 3.65, or higher, while carrying a minimum academic load of 12 quarter hours.

GRADUATION WITH HONORS. The award of the Master of Science degree may be made "With Distinction" when a student completes the degree requirements with a minimum of 32-quarter hours earned in residence and is in the upper 10% of the graduating class. The award of a Bachelor's degree may be made "Cum Laude" when a student completes the degree requirements with a minimum of 60-quarter hours in residence and is in the upper 5% of the graduating class.

SIGMA XI. The Naval Postgraduate School has a Chapter of the Society of the Sigma Xi, an honorary society founded to recognized excellence in the scientific and engineering disciplines. Students who have demonstrated marked promise in their research work are considered for membership each year. The number elected is limited only by the quality of the research work done for a graduate degree.

MEWBORN STUDENT RESEARCH AWARD. This award affords recognition for exceptional research talent. It is awarded annually to a student in a program of graduate scientific or engineering studies, leading to an advanced degree, whose thesis exhibits sound scholarship and outstanding research ability.

CAPTAIN J. C. WOELFEL AWARD. This award is given annually to the United States Naval Officer student receiving an advanced degree in the Naval Engineering Programs who has demon-

strated the most outstanding academic record, and at the same time possesses those attributes best exemplifying a Naval Officer.

W. RANDOLPH CHURCH AWARD. This award is given annually to a student on the basis of his performance in mathematics courses. The criteria for selection will include evidence of initiative, scholarly attitude and mathematical maturity. The student need not be a mathematics major, nor must he be a graduate at the time of presentation.

NAVAL ELECTRONIC SYSTEMS COMMAND AWARD IN ELECTRONICS ENGINEERING. This award will be given semiannually to a Master of Science candidate in the Advanced Electronics Engineering Program who has a most outstanding academic record and whose qualities indicate an outstanding military officer.

NAVY LEAGUE OF MONTEREY AWARD FOR ACADEMIC IMPROVEMENT. This award is presented quarterly to the graduating Navy, Marine Corps, or Coast Guard student (less Ph.D. candidates) who has demonstrated outstanding academic achievement during his enrollment at NPS. The award is made primarily on the basis of the student's academic improvement.

ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION AWARDS. Up to three of these awards may be presented each quarter to graduates of the Communications and Engineering Electronics curricula who have demonstrated the highest scholastic achievement.

NAVAL SEA SYSTEMS COMMAND AWARD IN NAVAL ENGINEERING. This award affords recognition to a graduate of any curriculum leading to a Master of Science degree in Mechanical or Electrical Engineering who has demonstrated academic excellence through attainment of a high Quality Point Rating in addition to an outstanding thesis, and who has exhibited leadership potential in the engineering area.

CHIEF OF NAVAL OPERATIONS AWARD FOR EXCELLENCE IN OPERATIONS RESEARCH. This award is presented semiannually to an outstanding United States Navy or Marine Corps graduate of the Operations Research/Systems Analysis curriculum. The award is made on the basis of academic record, performance during the student's experience tour, and faculty recommendations.

ADMIRAL WILLIAM ADGER MOFFETT AWARD. This award is presented annually to an outstanding graduate of the Aeronautical Engineering curriculum. The award is made on the basis of the student's academic excellence, including thesis, and his career potential.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS AWARD. This award is presented semiannually to the graduate in an advanced communications degree program achieving an outstanding academic record and exhibiting those qualities indicative of an outstanding military officer.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS CER-

TIFICATE. This certificate is presented quarterly to the Master of Science graduate who shows the greatest academic improvement in a communications curriculum.

CHIEF OF NAVAL OPERATIONS ASW AWARD. This award is given annually to the most outstanding student graduating from the antisubmarine warfare curriculum.

DIRECTOR OF NAVAL INTELLIGENCE GRADUATION AWARD. This award is presented annually to recognize the most outstanding student in the Naval Intelligence curriculum.

NAVAL SEA SYSTEMS COMMAND AWARD IN WEAPONS ENGINEERING EXCELLENCE. This award is given annually to the most outstanding officer graduate of the Weapons Systems Engineering curricula.

NAVAL UNDERWATER SYSTEMS AWARD IN SUBMARINE WARFARE SYSTEMS. This award is given annually to the officer student graduate who has demonstrated the greatest contribution in the field of submarine warfare systems.

## SUPERINTENDENT'S GUEST LECTURE PROGRAM

Throughout the Academic Year lectures will be presented on Tuesday afternoons in King Hall for students, faculty and staff. Eminently qualified civilian and military authorities from a wide range of fields and accomplishments will speak on subjects of current and historical interest in international, government sociological, and military affairs. Occasionally speakers are presented in the evening with wives also invited to attend. The primary purpose of this series is to inform as well as to stimulate and challenge the thinking of the officer students in areas outside of their immediate academic pursuits.

## NAVAL POSTGRADUATE SCHOOL FOUNDATION

The Foundation is a non-profit corporation whose purposes are:

> "to solicit, receive, and administer contributions and make donations and dispense charitable contributions . . . and otherwise aid, encourage and support the traditions of the Naval Postgraduate School . . ."

The corporation was formed in December 1970, and has since served as a vehicle by which large and small tax-exempt gifts have been easily and quickly given to the School. These gifts are all applied to those needs or purposes which would otherwise — in these days of severe fiscal restraint — be poorly- or not-at-all funded.

The Rear Admiral John Jay Schieffelin Award for Excellence in Teaching was endowed through the Foundation. A black granite sculpture, FLIGHT, located in the Dudley Knox Library, was donated to help publicly honor the recipients of this prestigious and valuable award.

The Foundation, in cooperation with the Office of Naval Research, administers the Carl E. Menneken Fellowship for Scientific Research. This annual award of $1,000 has the dual objectives of furthering the progress of engineering and science

in areas of importance to the Navy and to provide aid to a worthy doctoral student involved in a research program expected to be of benefit to the Navy. The award honors the memory of Carl E. Menneken who devoted his career to the Navy as Distinguished Professor of Electronics and Dean of Research Administration at the Postgraduate School.

Dependents graduating from high school while their sponsor is attached to the Naval Postgraduate School are eligible for scholarships offered by the Naval Postgraduate School Foundation. These scholarships are based entirely on merit, and are usually awarded in the amount of $500 per recipient.

The School's Sailing Association owes the majority of its present assets to donations made to the Foundation. Small donations have also been received from some "friends of the Library" who wished to create a small but meaningful and useful memorial.

The Directors of the corporation are civilians, except for the Superintendent who serves to assure that only gifts appropriate to the School are accepted.

Individuals wishing to participate in the work of the Foundation may write to the Secretary, Naval Postgraduate School, Monterey, California 93940.

## CIVILIAN EDUCATION PROGRAM

All civilian employees of the United States government are eligible to enroll in the courses, curricula, and degree programs of the School. Enrollment is subject to the approval of the individual's employing agency for his participation. An individual may enroll in one of the regular curricula designed for officers, in a specially designed degree program, in a selection of courses making up a non-degree program, or in a Continuing Education course.

*Regular Curricula.* The School's programs for officers are designed to meet the requirements of the services for specific education. Civilian students may enter any curriculum at the point at which they are qualified and complete the curriculum along with the officer students. The available curricula are described later in the catalog.

*Degree Programs.* For a civilian student, an individual program can be tailored to meet his educational needs while leading to the award of a graduate degree. The program can be designed to meet the degree requirements in a minimal time. A preparatory phase (off-campus), designed to minimize the residency requirement, is developed in consultation with a School advisor and may include courses at a local university, self-study courses from the School, and other appropriate activities. The residency phase, usually one year or less in length, entails completing the course work, passing any required qualifying examinations, and starting a thesis project. The third phase (on- or off-campus) involves completion of the thesis project.

Degree programs are described in the departmental descriptions. Those available include Masters degrees in the areas of Naval Intelligence, National Security Affairs, Operations Research, Finan-

cial Management, Personnel Management, Systems Acquisition Management, Telecommunications Systems, Command Control and Communications (C3), Computer Systems Management, Material Management, Human Resources Management, Mathematics, Physics, Meteorology, Oceanography, Aeronautical Engineering, Mechanical Engineering, Electrical Engineering, Systems Technology, Applied Science, Anti-Submarine Warfare, Electronic Warfare, Avionics, and Computer Science.

Engineer degree programs and the Doctor of Engineering degree are available in Aeronautical, Electrical and Mechanical Engineering.

The Doctor of Philosophy is given in Physics, Oceanography, Meteorology, Operations Research, Aeronautical Engineering, Electrical Engineering and Mechanical Engineering.

*Non-Degree Programs.* Prospective civilian students may desire to pursue a program for professional advancement without a degree objective. Any of the School's regular courses are available for such efforts. For groups of employees from an agency, special course offerings can be developed to meet particular requirements, provided the demand is in an area of expertise of the School.

*Continuing Education.* The opportunities available include short course offerings both on and off campus, as well as self-instructional courses for credit to be taken individually. The Continuing Education program is given in detail in the following section.

There are no formal requirements for enrollment in the Continuing Education Program or for a non-degree program. For admission to a program leading to a graduate degree, the minimum qualification is an accredited baccalaureate degree with appropriate preparation for the proposed degree program. The School will require submission of official transcripts covering all college work completed to date. In some cases, submission of Graduate Record Examination Aptitude test scores may be requested.

The point of contact for information pertaining to on campus programs and admission to degree programs is the Dean of Academic Administration, Code 014, telephone (408) 646-2392 or Autovon 878-2392. For information concerning continuing education, the contact point is the Executive Director of Continuing Education, Code 500, telephone (408) 646-2558 or Autovon 878-2558.

## CONTINUING EDUCATION PROGRAM

The Naval Postgraduate School Continuing Education (NPSCE) Program was established in June 1974 as a means of providing extended educational services that will more comprehensively fulfill the school's assigned mission. These extended services include the offerings of self-study credit courses off campus; the delivery, both on and off campus, of professionally relevant short courses; and expanded educational counseling. The self-study credit course offerings are listed in the annual Catalog of Self-Study courses which has wide distribution.

CNETINST 1520.8 (29 August 74) is the authenticating instruction for NPSCE program. This program is administered by the Continuing Education Office.

Selected graduate preparatory courses are delivered off campus in a self-study self-paced mode for the same academic credit as received when taken on campus. These self-study courses are delivered to officers at their current duty stations for completion during off-duty hours or work/study periods. They have been selected from courses normally taken in the initial phase of curricular programs at the Naval Postgraduate School. Their successful completion will enhance selection for postgraduate education, enhance performance in early phases of graduate education programs, and reduce course requirements in curricular programs at the Naval Postgraduate School. The delivery of a self-study credit course normally requires the local participation of a qualified tutor (e.g., a civilian or officer with requisite graduate education).

Application for enrollment in a self-study course may be made at any time. Applicants may use the appropriate form contained in the last section of the self-study catalog or write a letter using the format specified in CNETINST 1520.8. Applications should be forwarded to Superintendent (Code 500), Naval Postgraduate School, via the command holding the applicant's service or personnel record in accordance with CNETINST 1520.8. Self-study courses are also available to civilian employees of the Federal government.

Commands with available funds may arrange for delivery on site of short courses to meet specific needs on a direct reimbursable basis to the Naval Postgraduate School. Delivery costs may be obtained from the Continuing Education Office.

More information on short courses and self-study courses is available from the Continuing Education Office, Code 500, Naval Postgraduate School, Monterey, CA 93940, or telephone (408) 646-2558 or Autovon 878-2558.

## ACADEMIC COUNSELING SERVICE

The Naval Postgraduate School has established an academic counseling service to assist officers in developing individual educational plans. Officers who have chosen specific curricula, or who have been selected or detailed for graduate education in curricular programs at the Naval Postgraduate School should direct inquiries to the appropriate curricular office. Specifically, requests for names of courses that can be taken in a self-study mode to prepare for specific curricula at the Naval Postgraduate School should be directed to the appropriate curricular officer.

The Naval Postgraduate School has been assigned the responsibility to prepare an abstract of each selected or newly commissioned Naval officer's academic background, leading to the development of a three-digit Academic Profile Code (APC), summarizing his pertinent academic qualifications. Officers seeking information about their APC or academic qualifica-

tions, should contact the Dean of Academic Administration, Code 014, Naval Postgraduate School, Monterey, CA 93940, or telephone (408) 646-2392 or AUTOVON 878-2392. Officers completing courses to upgrade their APC should forward transcripts (not grade reports) to Code 0145 at the Naval Postgraduate School.

Officers not yet selected for graduate education seeking general information about sub-specialty codes, selection for graduate education, and preliminary information about graduate education commensurate with career fields should contact the Office of Continuing Education, Code 500, Naval Postgraduate School, or telephone (408) 646-2984 or AUTOVON 878-2984.

Inquiries pertaining to curricula not offered at the Naval Postgraduate School should be directed to Manager, Civilian Institution Program, Naval Postgraduate School, Monterey, CA 93940, or telephone (408) 646-2319 or AUTOVON 878-2319.

## W. R. CHURCH COMPUTER CENTER

### STAFF

**Douglas George Williams**, Professor and Director (1961)*; M.A. (Honours), Univ. of Edinburgh, 1954.

**Roger Rene Hilleary**, Manager, User Services (1962); B.A., Pomona College, 1953; M.S., Naval Postgraduate School, 1970.

**Edward Norton Ward**, Manager, Systems Programming (1959); B.A., Univ. of California at Los Angeles, 1952.

**David Fredric Norman**, Manager, Operations (1969).

**Kristina Louise Butler**, User Registration and Accounting (1970).

**Lois May Brunner** (1961); B.S. Naval Postgraduate School, 1968.

**Hans Welter Doelman** (1967); B.S., Univ. of California at Berkeley, 1956.

**Richard Eugene Donat** (1968); B.S., California State Polytechnic Univ., 1967.

**Lloyd George Nolan** (1971); B.S., Colorado State Univ., 1968.

**Bernadette Requiro Peavey** (1967); B.A., Univ. of California at Berkeley, 1963.

**Sharon Dill Raney** (1964); B.S., California State Polytechnic Univ., 1964. M.S., Naval Postgraduate School, 1977.

**Kathryn Betty Strutynski** (1967); B.S., Brigham Young Univ., 1953.

**The year of joining the Postgraduate School is indicated in parentheses.*

The Naval Postgraduate School was one of the first educational institutions to use digital computers in its instructional and research programs. The first machine, an NCR 102A, was installed in 1954 and operated by the Department of Mathematics. A central Computer Facility was created in 1960 as an organizational unit separate from the academic

departments. In December, 1969, the Facility was renamed the "W. R. Church Computer Center" in memory of Professor Church, Chairman of the Department of Mathematics (1947-66) who recognized very early the value of computers in education and was instrumental in obtaining the first computers at the School.

The many services of the Center are available to all faculty, staff, and students of the School for use in connection with instruction, research, or administrative activities.

These services are based on an IBM 360, Model 67 computer system which was installed in April 1967. The present hardware complement includes two Model 67 processing units; four different levels of storage, including 2 million bytes of core, four million bytes on a drum, 24 disk drives with 29 million bytes each and 10 drives with 100 million bytes each, nine magnetic tape units; two high-speed plotters, 50 remote hardcopy and video terminals, and an IBM 2250 Graphical Display Unit. The two processors are identical and can access directly, or control, all components of the system including core storage modules, input/output controllers and devices. The resources of the system can be allocated easily to create different operational environments.

The Center offers users two modes of operational service, viz., batch-processing (under OS/MVT with HASP) and general-purpose, time-sharing (under CP/CMS). Both operating systems offer a great variety of programming languages, libraries of subroutines and other software facilities. Language support includes FORTRAN IV, WATFOR, Assembler, COBOL, APL, PL/1, BASIC, ALGOLW, GPSS and SIMSCRIPT.

The School has a heavy commitment to computers consistent with their present and future role in military operations. All of the academic curricula have been affected by the presence of computers on campus. The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. All graduate students take at least one course in computer science. They are introduced to the computer early in their curricula at the Naval Postgraduate School and encouraged to use it in subsequent course work and research.

The Computer Center supports a wide variety of specialist courses in computer science offered by the Departments of Computer Science, Electrical Engineering, Mathematics, Operations Research and Administrative Sciences.

The Center has a staff of 24 people of whom 11 are mathematician/programmers. The professional staff provides a consulting service in applications programming, systems programming and problem formulation to students and faculty members. They participate in an active research and development program directed primarily towards improving the present operational environment or introducing new hardware and software facilities to users. Current projects include work on systems measurement, improvement of operating systems, graphical data processing, time-sharing facilities, and numerical analysis.

In 1975 the Center began to provide data processing support to the tenant activity. Defense Manpower Data Center (DMDC).

# DUDLEY KNOX LIBRARY

## STAFF

**Paul Spinks**, Associate Professor and Director of Libraries (1959)*; B.A., Univ. of Oklahama, 1958; M.S., 1959.

**Mary Therese Britt**, Assistant Professor and Associate Director of Libraries (1966); B.S., College of St. Catherine, 1947.

**Mary Frances Bedford**, Acquisitions Librarian (1977); B.A., Univ. of California at Santa Cruz, 1975; M.S., Univ. of California at Berkeley, 1976.

**Pasco Domenic Collelo**, Research Reports Librarian (1973); B.S., Brown Univ., 1951; M.A., California State Univ. at San Jose, 1972.

**Julie Ellen Diepenbrock**, Cataloging Librarian (1978); B.A., Wheaton College, 1972; M.S., Univ. of Maryland, 1975.

**Noel William Johnson**, Assistant Professor and Head Research Reports Librarian (1970); B.A., Univ. of Nevada, 1949; B.S., Univ. of California at Berkeley, 1954.

**Roger McQueen Martin**, Reader Services Librarian (1974); B.S., Univ. of Texas, 1949; M.S., 1958.

**Caroline Jeannette Miller**, Cataloging Librarian (1975); B.Ed. Sec., Univ. of Hawaii, 1966; M.S., Univ. of Rhode Island, 1972.

**Diane Shirley Nixon**, Head Acquisitions Librarian (1969); B.A., California State Univ. at Fullerton, 1968; M.S., Univ. of Southern California, 1969.

**Louis Oven**, Cataloging Librarian (1969); B.A., Monterey Institute of Foreign Studies, 1964; M.A., Univ. of California at Berkeley, 1968.

**Cleo Elizabeth Peterson**, Research Reports Librarian (1958); A.A., Red Oak College, 1938.

**Frances Emanuela Maria Strachwitz**, Research Reports Librarian (1970); B.S., Dominican College of San Rafael, 1951; M.A., Univ. of Denver, 1968.

**Helen Jeanette Waldron**, Head Cataloging Librarian (1975); B.A., Univ. of Washington, 1937; M.A., Univ. of California at Berkeley, 1951.

**The year of joining the Postgraduate School is indicated in parentheses.*

The Dudley Knox Library, a building of 50,000 square feet, was dedicated in 1972. The collections housed therein serve the research and instructional needs of the community, comprising students, faculty and staff of all departments of the Postgraduate School. They embrace an active collection of 172,000 books, bound periodicals and pamphlets; 16,000 monographic and journal volumes in microform; 169,000 research reports in hard copy and 170,000 in microform; and over 1,800 periodicals and other serial publications currently received. These materials parallel the School's curricular fields of engineering, physical sciences, managerial sciences, operations research, naval sciences, and national security affairs.

The Reader Services Division provides the open literature sources, such as books, periodicals and journals, indexes and abstracting services, pamphlet materials and newspapers. It provides access to more than 85 computer data bases in

the curricular fields of interest by means of DIALOG On-Line Information Retrieval Service (Lockheed Information Systems) and CIRC (Central Information Reference and Control), Foreign Technology Division Center, AFSC, Wright-Patterson Air Force Base. It furnishes facilities for microform reading and printing and for reproduction of printed matter. It borrows publications not held in its collections from other libraries.

The Research Reports and Classified Materials Division is the principal repository for research documents received by the School. It houses the Library's classified and unclassified research reports in hard copy and microfiche. A machine information storage and retrieval system that utilizes the School's computer facilities is available for bibliographic searches of research and development documents held by the division. An SDI (Selective Dissemination of Information) Service is also available. In addition, the Division is now able to perform, via its own remote terminal, computer searches of the data banks of the Defense Documentation Center in Alexandria, Virginia, and thus to provide rapid and efficient access to the 800,000 documents held by the Center.

The Christopher Buckley, Jr., Library is located on the second floor of the Library. It is a collection of some 8,000 volumes pertaining principally to naval history and the sea. The establishment of this collection was made possible by the interest and generosity of Mr. Christopher Buckley, Pebble Beach, California, who began donating books to the School for this Library in 1949.

# CURRICULAR OFFICES and PROGRAMS

The curricular offices are staffed by military Curricular Officers and civilian-faculty Academic Associates. They share the responsibility of developing, maintaining and updating curricular programs that are academically sound and meet the professional needs of the Department of Defense. Each officer student is assigned to an appropriate curricular office for academic and military counseling and supervision.

This section of the catalog includes descriptions of all regularly sponsored curricula offered at the Naval Postgraudate School. Specific academic requirements for enrollment are contained within the portion relating to each curriculum. In general, the more technical curricula require mathematics through calculus and varying levels of scientific or engineering courses.

Students with academic deficiencies in mathematics or science are encouraged to take advantage of the Naval Postgraduate School's Continuing Education offerings. An opportunity also exists for some students to enter a technical curriculum as indirect inputs via the Engineering Science Program (#460). This preparatory program for one or two quarters' duration, is tailored to each student's needs.

The curricular programs typically include an introductory phase wherein a student completes the required preparatory courses before undertaking graduate-level studies. Many of the preparatory courses are available for off-campus self-study through the Office of Continuing Education.

Prospective students are encouraged to communicate with the cognizant Curricular Officer by letter or telephone for counseling regarding the particular off-campus courses they may require to qualify for enrollment in a given curriculum and those that would serve to strengthen their preparation for its graduate program.

# CURRICULAR OFFICES

| Title | Organizational Code | AUTOVON |
|---|---|---|
| Administrative Science | 36 | 878-2536 |
| Aeronautical Engineering | 31 | 878-2491 |
| Antisubmarine Warfare | 331 | 878-2116 |
| Command, Control and Communications (C3) | 39 | 878-2772 |
| Computer Technology | 37 | 878-2174 |
| Electronics and Communications | 32 | 878-2056 |
| Environmental Sciences | 35 | 878-2044 |
| Naval Engineering | 34 | 878-2033 |
| Naval Intelligence/National Security Affairs | 38 | 878-2228 |
| Operations Research/Systems Analysis | 30 | 878-2786 |
| Weapons Engineering | 33 | 878-2116 |

## CURRICULA

| Curriculum | Curriculum Number | Normal Length (Months) | Normal Convening Dates | Cognizant Curricular Office Code |
|---|---|---|---|---|
| Administrative Science | | | | |
| (Material Movement) | 813 | 12-18 | July | 36 |
| (Procurement Management) | 815 | 12-18 | January, July | 36 |
| (USMC, USCG, USA and Allied Officers) | 817 | 12-18 | January, July | 36 |
| (Systems Inventory Management) | 819 | 12-18 | January, July | 36 |
| (Material Management) | 827 | 12-18 | January, July | 36 |
| (Financial Management) | 837 | 12-18 | January, July | 36 |
| (Manpower/Personnel Management) | 847 | 12-18 | January, July | 36 |
| (Human Resources Management) | 857 | 12-18 | January, July | 36 |
| Aeronautical Engineering | 610 | 18-24 | Any Quarter | 31 |
| Aeronautical Engineering-Avionics | 611 | 18-24 | Any Quarter | 31 |
| Air-Ocean Science | 373 | 18-24 | Any Quarter | 35 |
| Antisubmarine Warfare | 525 | 24 | March | 331 |
| Command, Control and Communications (C3) | 365 | 18 | September | 39 |
| Communications Engineering | 600 | 18-27 | Any Quarter | 32 |
| Computer Science | 368 | 18-21 | March, September | 37 |
| Computer Systems | 367 | 12-15 | March, September | 37 |
| Electronic Warfare - Engineering | 591 | 18-27 | March, September | 32 |
| Electronic Warfare Systems Technology | 595 | 18-24 | March | 32 |
| Engineering Electronics | 590 | 18-27 | Any Quarter | 32 |
| Engineering Science | | 6 | March, September | |

| | | | | |
|---|---|---|---|---|
| Meteorology | 372 | 18-24 | Any Quarter | 35 |
| National Security Affairs | | | | |
| (Middle East, Africa, South Asia | 681 | 12-24 | Any Quarter | 38 |
| (Far East, Southeast Asia, Pacific) | 682 | 12-24 | Any Quarter | 38 |
| (Europe, USSR) | 683 | 12-24 | Any Quarter | 38 |
| (International Organizations and Negotiations) | 684 | 12-18 | Any Quarter | 38 |
| (Strategic Planning) | 686 | 12-18 | Any Quarter | 38 |
| Naval Engineering | 570 | 18-27 | Any Quarter | 34 |
| Naval Intelligence | 825 | 18 | Any Quarter | 38 |
| Oceanography | 440 | 18-24 | Any Quarter | 35 |
| Operations Research/ Systems Analysis | 360 | 18-24 | March, September | 30 |
| Systems Acquisition Management | 816 | 15-16 | March, September | 36 |
| Telecommunications Systems | 620 | 15-18 | September | 32 |
| Underwater Acoustics | 535 | 18-24 | September | 33 |
| Weapon Systems Science | 531 | 18-24 | March, September | 33 |
| Weapon Systems Technology | 530 | 18-24 | March, September | 33 |

# ADMINISTRATIVE SCIENCE PROGRAMS CURRICULA NUMBERS 813, 815, 816, 817, 819, 827, 837, 847, 857

**Kent A. Link**, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1959; M.S. in Management, Naval Postgraduate School, 1974.

**Joseph Dominic Monza**, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.A., Geneva College, 1959; M.S. in Management, Naval Postgraduate School, 1970.

**James Kenichi Arima**, Academic Associate for Manpower/Personnel Management (847); B.A., Univ. of California at Los Angeles, 1948; M.A., George Washington Univ., 1957; Ph.D., Northwestern Univ., 1962.

**Alexander Clayton Crosby**, Commander, U.S. Navy; Academic Associate for Procurement (815); B.S., Univ. of California at Berkeley, 1957; MBA Harvard Univ., 1972.

**Carson Kan Eoyang**, Academic Associate for Human Resources Management (857); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

**James Morgan Fremgen**, Academic Associate for Financial Management (837); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

**James Kern Hartman**, Academic Associate for Administrative Science Programs (817); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

**Melvin Bernard Kline**, Academic Associate for Systems Acquisition Management (816); B.S., College of the City of New York, 1941; M.S., Stevens Institute of Technology, 1952; M.E., Univ. of California at Los Angeles, 1959; Ph.D., 1966.

**Alan Wayne McMasters**, Academic Associate for Systems Inventory Management (819) and Material Management (827); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

**Robert William Sagehorn**, Lieutenant commander, U.S. Navy; Academic Associate for Material Movement (813); B.S., California Maritime Academy, 1959; B.A., Naval Postgraduate School, 1970; M.S., 1975.

## ADMINISTRATIVE SCIENCE CURRICULA (GROUP MN)

CURRICULUM 813 — Material Movement

CURRICULUM 815 — Procurement Management

CURRICULUM 817

- Allied Officers — Various Management Options
- U.S. Army — Operations Research Systems Analysis (Business)
- U.S. Marine Corps — Defense Systems Analysis
- U.S. Coast Guard — Management Science

CURRICULUM 819 — Systems Inventory Management

CURRICULUM 827 — Material Management

CURRICULUM 837 — Financial Management

CURRICULUM 847 — Manpower/ Personnel Management

CURRICULUM 857 — Human Resources Management

OBJECTIVES — These programs are designed to:

— provide the officer with the specific functional skills required to effectively manage in a subspecialty area.

— provide the officer with the Navy/Defense Systems oriented graduate management education.

— enable the officer to evaluate the written research, study, and analysis product of others throughout his career.

— provide the officer with fundamental interdisciplinary techniques of quantitative problem-solving methods, behavioral and management science, economic analysis, and financial management.

QUALIFICATIONS FOR ADMISSION — A Baccalaureate degree with above average grades is required. Completion of at least two semesters of college mathematics at the level of college algebra or trigonometry is considered to be the minimum mathematical preparation.

DESCRIPTION — These curricula are interdisciplinary programs which integrate mathematics, accounting, economics, behavioral science, management theory, operations/systems analysis, and a subspecialty concentration area into an understanding of the process by which the defense mission is accomplished. Subspecialty concentration areas are specified by ordering officers into a specific curriculum.

Officers successfully completing the program will be awarded the degree of Master of Science in Management. In addition, Naval officers who complete one of the approved programs are awarded an appropriate subspecialty code (P-code).

Officers from the U.S. Services as well as allied officers start the curriculum with widely varied academic backgrounds. Each student's prior academic work and related military experience is evaluated for courses previously completed and applicable to the student's curriculum so that academic credits may be transferred. Validation or credit by examination is encouraged where knowledge of the material has been acquired by experience or service courses. A course load of 16 credit hours per quarter will be programmed.

## FUNDAMENTALS PROGRAM

This portion of the curriculum is generally preparatory in nature and portions of it may be validated by the officer with appropriate experience or academic background. The courses contained in the Fundamentals Program are considered prerequisites to the four quarters of graduate work. Officers can enhance their selectability for Administrative Science curricula by completing prerequisite courses, or their equivalents, through off duty education, including courses available through the NPS Office of Continuing Education.

The Fundamentals Program offers the following areas of study:

Mathematics for management and probability
Micro and macro economics
Financial and managerial accounting
Individual and organizational behavior
Data processing

## GRADUATE PROGRAM

The general Graduate portion of each program includes courses in the following areas:

- Statistics
- Operations research for management
- Public policy processes
- Systems analysis
- Management information systems
- Personnel management and labor relations
- Management policy

Specific courses pertaining to the various curricula include the following:

### Material Movement (813)

Curriculum Courses
- Material logistics
- Transportation management
- Transportation policy

Decision making for financial management

Electives
- Project management
- Procurement and contract administration
- Production management
- Selected topics in logistics

### Procurement Management (815)

Curriculum Courses
- Procurement planning and contract negotiation
- Contract administration
- Procurement policy
- Project management
- Decision making for financial management

Electives
- Material logistics
- Production management
- Cost estimation
- Public expenditure, policy and analysis

### Defense Systems Analysis (817-USMC)

Curriculum Courses
- Procurement and contract administration
- Financial management in the Navy
- Cost estimation

Electives — Two from List A, one from List B. Substitutes with permission of Marine Corps Representative and the Curricular Officer.

LIST A

Analysis of Bureaucracy
Internal control of auditing
Decision making for financial management
Cost accounting

LIST B

Manpower economics
Decision analysis
Public expenditure analysis
Microeconomic theory and policy
Theory of systems analysis

### Management Science (817-USCG)

Required Courses
- Personnel management processes I*
- Personnel management processes II*
- Financial Control Systems

*These replace Personnel management and labor.

Curriculum Courses (select available electives minimum of 3 of the 4 groups)

GROUP 1

- Decision Analysis
- Search theory and detection
- Data analysis
- System simulation

GROUP 2

- Manpower requirements determination
- Planning and control
- Leadership and group behavior
- Other manpower personnel management courses

GROUP 3

Project Management
Manpower Economics
Cost estimation
Defense expenditure and policy analysis
Public expenditure policy and analysis

GROUP 4

Procurement and contract administration
Material logistics
Internal control and auditing
Decision making for financial management
Procurement policy

### Operations Research/Systems Analysis Business (817-USA)

Fundamentals Required Courses

Computational matrix algebra*
Calculus and vector analysis*

*These replace Math for management and probability.

Curriculum Required Courses

Linear programming
Operations research of Army weapons systems
Probability and statistics for management I, II

Curriculum Elective Courses (Choice of Three)

Stochastic models
Combat models
Cost estimation
Nonlinear and dynamic programming
Networks, flows and graphs
Inventory
Operations research methodology
Human factors in systems design
Decision analysis

### Systems Inventory Management (819)

Curriculum Required Courses

Material logistics
Decision making for financial management
Inventory
Seminar in supply systems

Curriculum Elective Courses

Inventory II
Project management
Production management
Transportation management
Production management

### Material Management (827)

Curriculum Courses

Aviation Maintenance Duty Officers:
Maintainability engineering
Systems effectiveness concepts and methods
Introduction to quality assurance
Supply Corps Officers:
Material management
Transportation management
Decision making for financial management
Inventory
Aviation Maintenance Officers and Supply Corps Officers:
Project management
Logistics engineering
Procurement and contract administration
Production management

Electives

Industrial relations
Internal control and auditing

### Financial Management (837)

Curriculum Required Courses

Decision making for financial management*
Financial management in the Navy
Financial control systems

*(required for Supply Corps officers; elective for all others)

Curriculum Elective Courses

Project management

Accounting theory and standards
Internal control and auditing
Cost accounting
Cost estimating

**Manpower/Personnel Management (847)**

Curriculum Required Courses

Personnel management process I, II
Manpower economics I, II
Manpower/personnel policy analysis
Manpower and personnel models
Manpower requirements determination

**Human Resources Management (857)**

Curriculum Required Courses

Defense resource allocation*
Behavior research methodology
HRM data assessment lab
Organization development I, II
Human resource development lab
HRM field work lab
workshop design lab
Analysis of bureaucracy
Education and training
Organization theory

*This replaces Public policy processes and systems analysis.

Curriculum Electives

Planning and control
Leadership and group behavior
Sociological analysis
Personnel performance evaluation
Personnel motivation
Industrial relations

**THESIS RESEARCH**

Twelve quarter hours are allocated for thesis research over the last two quarters of the Graduate Program. The thesis subject will be appropriate to the subspecialty area being prepared for.

## SYSTEMS ACQUISITION MANAGEMENT CURRICULUM CURRICULUM NUMBER 816 (GROUP SM)

OBJECTIVE — To provide graduate level education in the fundamental concepts, methodology, and analytical techniques required for the life cycle management of the planning and acquisition of defense systems. This curriculum is designed to meet the military's expanding needs for acquisition management personnel at headquarters and related activities having system acquisition management responsibilities.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above-average grades is required. Completion of differential and integral calculus is considered minimal mathematical preparation. Undergraduate majors in engineering or physical science are highly desirable, though other majors may be acceptable if the officer's experience demonstrates acquired technical competence.

DESCRIPTION — The curriculum consists of basic core courses which provide the fundamental disciplines essential to the acquisition process. Advanced courses are concerned with the structure of acquisition management in the Department of Defense and the decisions required of the acquisition manager. An appreciation of the forces at work in industry and within the executive and legislative branches of government and how these forces impact on systems acquisition policies and procedures is fostered throughout the program. Elective courses are available to enable the student to gain additional knowledge in acquisition areas of particular interest.

Classroom instruction stresses theoretical concepts as well as real world problem-solving through lectures, case studies, problem exercises and computer simulation exercises. Field trips to industrial

and military activities are also utilized to reinforce and further develop classroom concepts.

This curriculum is available to officers from the U.S. military services and allied officers on an individual case basis. Upon successful completion, graduates are awarded the Master of Science in Management. U.S. Naval officers are also awarded the appropriate subspecialty billet code. Matriculation occurs annually in September. Entry at other times may be coordinated with the curricular officer on a case basis.

Classroom instruction is supplemented by a weekly guest lecturer seminar which affords the student an opportunity to participate in discussions with senior military officers, industry executives, and officials from governmental agencies.

FUNDAMENTALS PROGRAM — Upon entry into the program each student's prior academic work and related military experience is evaluated by the Curricular Office. As a result of this evaluation, academic credits for courses previously completed and applicable to the Systems Acquisition Management curriculum will be transferred. In addition, validation or credit by examination is encouraged where knowledge of the materials has been acquired by experience or service courses. Fundamental courses include:

- Financial and managerial accounting
- Individual and group behavior
- Principles of project management organizations
- Systems engineering
- Industrial economics
- Introduction to computers
- Probability

GRADUATE PROGRAM — Courses in the graduate program include:

- Introduction to systems acquisition
- Manpower planning and analysis
- Procurement management
- Production management
- Economic analysis in defense
- Public expenditure policy and analysis
- Statistics
- Operations research
- Reliability
- Maintainability
- Logistics

Electives

Students are allowed two elective courses, one of which must be taken in the Financial Management area. Students who validate fundamental courses will have additional elective courses available, or may be able to shorten their length of program.

THESIS RESEARCH: The equivalent of three courses are devoted to thesis research over the last two quarters of the Graduate Program.

# AERONAUTICAL ENGINEERING PROGRAMS CURRICULA NUMBERS 610 AND 611

**Gerald Lee Devins,** Commander, U.S. Navy; Curricular Officer; B.S. in Engineering Electronics, Naval Postgraduate School 1965; M.S. in Engineering Electronics, 1967; M.S. in Management, 1976.

**Robert Diefendorf Zucker,** Academic Associate; B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

OBJECTIVE — To provide advanced professional knowledge in the field of Aeronautical Engineering.

ENTRANCE REQUIREMENTS — Mathematics through differential and integral calculus. A baccalaureate degree, or equivalent, is required, preferably in engineering or physical science. Students not meeting these requirements may be accommodated through special preparatory work.

WHO CAN ATTEND — Naval aviation officers, officers of other U.S. services, and civilian employees of the U.S. Government. Allied officers may also enroll, subject to the exclusion of particular classified courses.

DEGREE EARNED — Master of Science in Aeronautical Engineering is included as part of the program. (Advanced programs are available through the Doctorate for a few selected students.)

DURATION OF PROGRAM — Up to two years, depending on the student's background and ability.

ENTRANCE DATES — Students may enter an Aero program at any time during the year.

DESCRIPTION — The Aeronautical Engineering Programs are designed to meet the specific needs of the Navy's Operational Technical Managerial System (OTMS) for technical managers with a broad-based graduate education in Aeronautical Engineering. The opportunity for aviation officers to enroll in one of the Aeronautical Engineering Programs is dependent on a number of factors, including personal motivation and preference, professional performance, academic background, needs of the Service, and officer availability. While an undergraduate degree in engineering is naturally preferred, special preparatory programs can accommodate officers with widely varying academic backgrounds. Included among the long list of "Aero" graduates are many officers who entered with non-engineering degrees in fields ranging from Architecture to History.

All Navy graduate programs exist solely to support the validated OTMS billet requirements. Each program has a Navy sponsor charged with the responsibility of identifying the educational skills to be covered by that program. For the Aeronautical Engineering Programs, the sponsor is Commander, Naval Air Systems Command (NAVAIR), and the subspecialty code assigned to graduates is either XX71P or XX72P. As with other programs at the Naval Postgraduate School, the sponsor-identified educa-

tional skill requirements for the Aeronautical Engineering Programs exceed the traditional requirements for a Master's Degree. Therefore, while qualifying for a subsequently code in aeronautical engineering, all "Aero" students also satisfy the academic requirements for the degree Master of Science in Aeronautical Engineering.

### PREPARATORY PHASE

Preparation for graduate study is tailored to each officer's background and is programmed for a minimum time consistent with his capability. Each student's academic transcript is evaluated for possible validation of courses in areas where a sufficiently strong record of achievement is evident. Validation or credit by examination is also possible.

Most subject matter in the preparatory program is available for off-campus study through the Continuing Education Office. All Aero material is structured in "mini-courses" of one credit hour to encourage rapid completion. Each officer is urged to complete as much of this material as possible before arriving on campus.

Individualized instruction in the preparatory courses enables officers to enter the program at any time. The following material represents the minimum coverage required for entry into the graduate phase:

- Linear algebra and vector analysis
- Calculus and differential equations
- Fluid-thermo-gasdynamics
- Flight structures and dynamics
- Aerodynamics-performance-stability
- Circuit theory and electronics

### GRADUATE CORE

After the preparatory program, students enter into a common Graduate Core designed to provide advanced knowledge in each of the four principal areas of aeronautics:

- Aircraft and missile propulsion
- Current aerodynamic analysis
- Flight vehicle structural analysis
- Stability and control of aerospace systems

In addition to the above, the Graduate Core includes work in advanced Aero laboratories together with extensive study of computer methods.

### ADVANCED GRADUATE PHASE

All students receive in-depth graduate coverage through elective courses in the following areas:

FLIGHT DYNAMICS — Covers the stability and control parameters of a flight vehicle, including optimal control, fly by wire, aeroelastic effects, flight evaluation techniques, and VSTOL technology.

FLIGHT PROPULSION — Covers the analysis of propulsion devices for aircraft and missiles along with current methods in the design of turbomachines.

GASDYNAMICS — Covers internal and external flows in the subsonic, transonic, supersonic and hypersonic regimes, including plasma flows and laser technology.

FLIGHT STRUCTURES — Covers the behavior of structural components under static and dynamic loads, including current design methodology and use of advanced fabrication techniques.

An important feature of Curriculum 610 is a comprehensive sequence in aircraft/missile design which comes near the end of the program.

Highlighting the final phase of Curriculum 611 are sequences in the following areas:

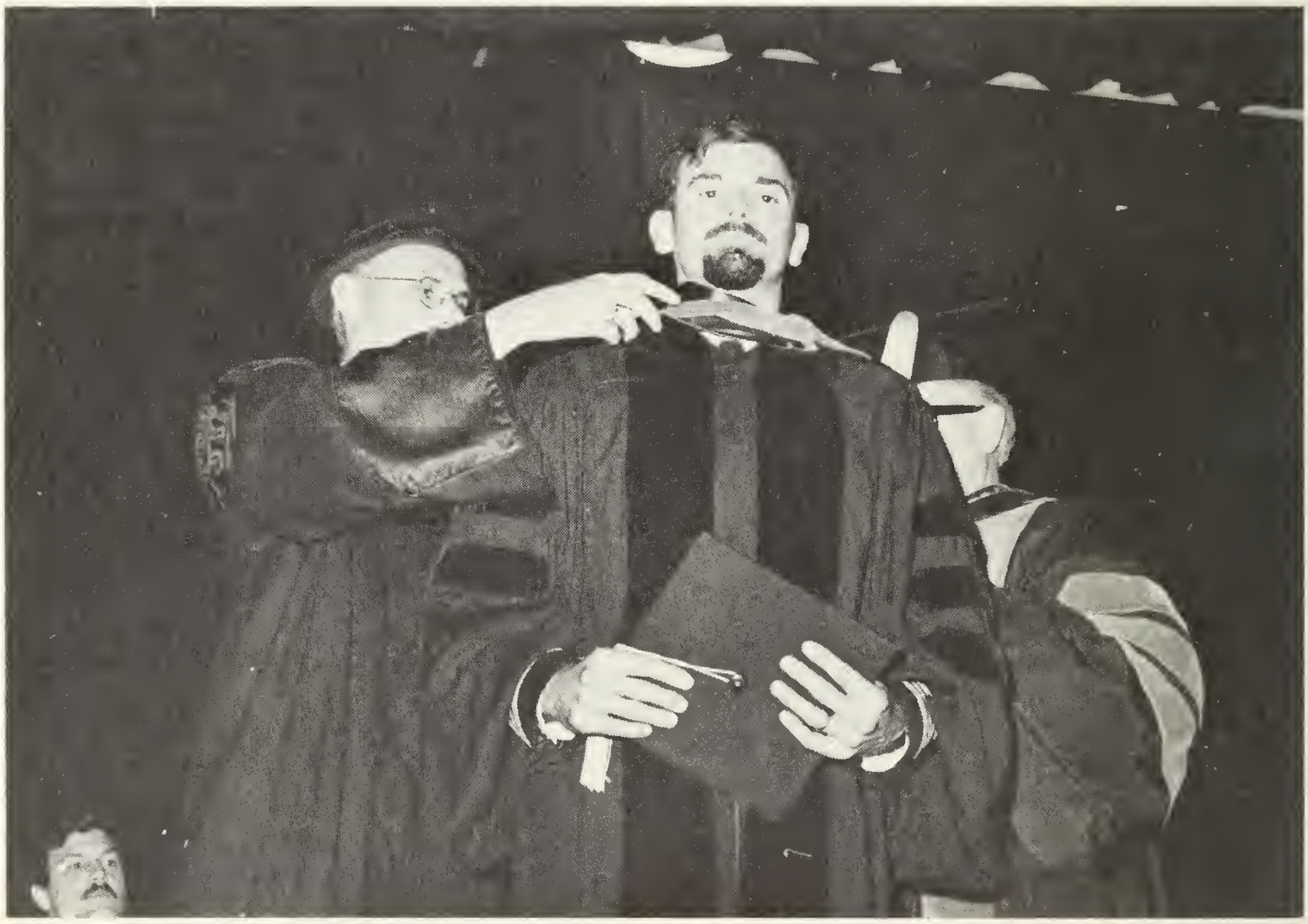
- Guidance and control
- Aero-computer science (with emphasis on micropressor applications)
- Electronic warfare

Overall, approximately 75% of the course work in Curriculum 610 is common to Curriculum 611, and the degree awarded in both is the Master of Science in Aeronautical Engineering.

Each student conducts research and prepares a thesis on a topic of his choice in areas such as: manned and unmanned flight vehicles, automatic landing systems, control of flight vehicles from hovering flight to hypersonic reentry, aircraft survivability/vulnerability, blast and shock effects, flight vehicle computer applications, electro-optics, or laser technology.

Extensive laboratory and computer failities

are available to supplement instructional and thesis research programs. In addition to the technical courses that form the structure of the graduate program and satisfy degree requirements, each student takes courses which are particularly relevant to Navy needs and professional development.



# ANTISUBMARINE WARFARE PROGRAM
# CURRICULUM 525

**Edward Joseph Mahon**, Commander, U.S. Navy; Curricular Officer, Antisubmarine Warfare Program; B.S., U.S. Naval Academy, 1957; B.S., Naval Postgraduate School, 1967.

**William Paul Kozain**, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer, Antisubmarine Warfare Program; B.S., State College, Slippery Rock, Pennsylvania, 1961; M.S., George Washington Univ., 1970; M.S., Naval Postgraduate School, 1975.

**John Norvell Dyer**, Academic Associate; B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

OBJECTIVES — This program is designed to:

— Educate officers in the fundamentals of engineering, the environment, and in the use of analytic techniques so that they can understand the basic phenomena which affect the capability of the ASW system(s) for which they are directly responsible.

— Educate officers in the fundamentals of "ASW Systems Engineering" so that they will be able to translate operational requirements into systems parameters to measure systems effectiveness, including the man-machine interface, and to view all of the components of a large system in proper perspective.

— Educate officers in the politico-military and decision making environment involving Soviet naval activities, net threat assessment and the Washington decision process.

— Develop officers' ability to analyze and develop ASW tactics, to evaluate ASW-related experiences critically, and to state clearly the nature of problems which are associated with ASW systems and operations.

— Provide officers with project-type, practice-oriented experience so that they will develop the ability to relate fundamental concepts directly to ASW operational application.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or equivalent with mathematics through differential calculus is required for direct input. Courses in the physical sciences and engineering are desirable. An additional qualification for entry into this curriculum is that selectees must have served in at least one ASW mission unit.

Officers not having the required academic qualifications for direct input enter the program indirectly through the Engineering Science curriculum discussed elsewhere in this catalog.

Officers may enhance their selectability by taking off-campus courses including participation in the Postgraduate School continuing education program which has been outlined earlier in the catalog.

DESCRIPTION — The structure of the curriculum takes into account the fact that the typical officer student has been away from an academic environment for some time and may not be ready to engage in graduate studies without some preparation. The extent of the preparation will depend upon the academic background of the individual officer and will be decided upon by the officer student in consultation with the Curricular Officer and Academic Associate.

The employment of systems in antisubmarine warfare involves complex man-machine interactions; it includes sonar, radar, weapon, communication and information systems and platforms. Therefore, this program is centered around a study of those systems used, and includes extensive breadth in appropriate scientific and technical disciplines. As a culmination of the program, about half of the time in the last six months is devoted to an ASW-related group project or thesis. This provides an opportunity to apply the graduate education and experience to a challenging project which interfaces with current needs in the ASW community.

This interdisciplinary, technical program integrates mathematics, physics, acoustics, electrical engineering, oceanography, operations analysis, human factors, computer science and meteorology. Several short projects are incorporated to further integrate the material presented in lectures and specialized laboratory exercises and to give practice in the systems approach.

The academic content divides naturally into four major discipline areas: Electrical Engineering with emphasis on signal processing; Underwater Acoustics with emphasis on signal propagation and detection; Operations Analysis with emphasis on tactical applications and decision analysis, and the Environment with emphasis on the air/ocean interface and environmental factors affecting sound in the sea.

Graduates of the ASW program receive the subspecialty designation XX44P and return to key operationally-oriented ASW billets ashore and afloat. As their careers progress within the Operational-Technical-Managerial Systems (OTMS) concept, they are prepared to perform in all three areas, particularly Operations, and will typically qualify for the Additional Qualification Designator (AQD) of AWS expert. Graduates are awarded the degree Master of Science in Systems Technology.

### INTRODUCTORY STUDY

This portion of the program is generally preparatory in nature and some portions of it may be validated by the officer with appropriate operational and academic experience. Because of the integrated nature of the course work in this curriculum, however, validation will be certified only after careful consideration and consultation with the Curricular Officer and Academic Associate.

Undergraduate courses are chosen to prepare students for graduate level work and typically cover the following areas:

- Elements of linear algebra, ordinary differential equations, and fourier series
- Vector calculus
- Partial differential equations and transforms for wave propagation
- Applied probability theory
- Descriptive statistics and operations research models
- Calculation and programming
- Computer systems
- Electronic systems
- Survey of oceanography
- Threat analysis
- Physics of sound in the ocean
- Meteorology for ASW

### GRADUATE STUDY

This portion consists of integrated course offerings in the several disciplines related to ASW. Typical graduate level topics are listed below:

- Study project on ASW systems performance
- Electromagnetic wave propagation
- Non-acoustic sensor systems
- The defense decision process and ASW Warfare

Computation and computer simulation
Fundamentals of acoustics
Underwater acoustics
Environmental factors in underwater acoustics
Environmental prediction for underwater sound propagation
Signals and noise
Signal processing systems
Search, detection and localization models
Combat models and weapons effectiveness
Decision analysis and data analysis
Human vigilance performance
Systems psychology
Intelligence

In addition to an ASW-related individual thesis or group project as the culmination of the program, each officer selects a three-course elective sequence in a specialty area. Examples of such areas are Operations Analysis, Underwater Acoustics, ASW Signal Processing, Human Factors, and Non-Acoustic Sensors. Throughout the program, seminars provide for guest speakers, discussions of ASW matters and other special activities.

This program convenes bi-annually in March and September.

*Students performing an acoustic experiment in an anechoic water tank.*

# COMMAND, CONTROL AND COMMUNICATIONS (C3) PROGRAM CURRICULUM NUMBER 365

**Francis Richard Murphy**, Lieutenant Colonel, U.S. Air Force, Curricular Officer; B.S., Florida Southern College, 1966; M.S. in Computer Science, Texas A&M Univ. 1969.

**Samuel Howard Parry**, Academic Associate; B.S. Georgia Institute of Technology, 1963; M.S. Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

OBJECTIVE — To provide officers through graduate education, with a comprehensive operational and technical understanding in the field of command, control and communications systems as applied to joint and combined military operations at the national and unified command levels. These officers are to be able to undertake a wide range of joint assignments in C3 over the full span of a career.

Graduates will be expected to:

- Apply operational experience and analytical methods in specification and evaluation of C3 systems.
- Identify and articulate joint C3 requirements.
- Develop joint C3 systems plans and policy.
- Manage C3 operations, including the use of ADP software.
- Adapt C3 system design and operations to counter electronic and physical vulnerabilities.

QUALIFICATIONS FOR ADMISSION — The C3 Curriculum is open to officers of all U.S. Military Services. Students are normally at the 0-3 and 0-4 grade level. Admission requires a baccalaureate degree with at least two years of mathematics and above average grades. Prior study of differential and integral calculus is strongly recommended. A Top Secret security clearance is required with Special Intelligence (SI) clearance obtainable. Classes convene annually, in September. The program is typically six quarters in duration.

DESCRIPTION — The Command, Control and Communications Curriculum is interdisciplinary in nature, consisting of course work in operations research, computer science, administrative science, electrical engineering, mathematics and national security affairs. A major goal of the curriculum is to provide the student enhanced capabilities to operate effectively in such diverse areas as military decision making, current and future C3 systems design, and joint military operations. The curriculum is tailored to the requirements of selected officers who have outstanding performance records and anticipate continued careers focused on the conduct of military operations.

### TYPICAL PROGRAM

Introductory Study. This portion of the program is preparatory in nature, and portions of it may be validated by a student with appropriate operational and academic experience. Subjects include:

- Elements of linear algebra, differential and integral calculus, ordinary differential equations, and Laplace transforms.
- Introduction to computer systems and programming.
- Introduction to electronic circuits and systems.

Graduate Study. Subjects include:

- C3 mission and organization
- Probability and statistics
- Information systems for C3

Decision and data analysis
Analytical planning models and methodology
Exercise Simulation and Evaluation
C3 Man/machine interaction
Interactive computer systems
Introduction to signals and noise
Electronic warfare and C3
C3 requirements determination
C3 exercise laboratory
National intelligence systems and products
Data base systems
Telecommunications networks
C3 policies and problems
Systems acquisition

Thesis. Twelve quarter hours are allocated for thesis research in the final two quarters.

Seminars. Integral to the program is a schedule of C3 related seminars with key military officers and civilians knowledgable in command, control and communications systems.

**Field Trip.** An orientation tour of major C3 facilities is conducted to allow the student to become familiar with existing C3 operations and associated problems.

**Degree.** Successful completion of the program leads to award of the degree of Master of Science in Operational Decision Systems.

*Extending congratulations at Graduation.*

# COMPUTER TECHNOLOGY PROGRAMS CURRICULA NUMBERS 367 AND 368

**Michael Charles Roth**, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1961; M.S. in Computer Science, Naval Postgraduate School, 1969.

**Norman Floyd Schneidewind**, Academic Associate for Computer Systems; B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (Engr), 1970; D.B.A., 1966.

**Uno Robert Kodres**, Academic Associate for Computer Science; B.A., Wartburg College, 1954, M.S., Iowa State Univ., 1956; Ph.D., 1958.

**Bruce Robert Johnsen**; LCDR, U.S. Navy, Assistant Curricular Officer; B.S., South Dakota School of Mines, 1959; M.S., Computer Systems Management, Naval Postgraduate School, 1974.

## COMPUTER SYSTEMS CURRICULUM CURRICULUM NUMBER 367

OBJECTIVES — This program is designed to:

— Provide the officer with the knowledge, skills, and practical understanding to evaluate changes and advances in the management of computers in the Military Services.

— Educate the officer in the technical aspects of computers and computer systems so that, in consonance with his management skills, he can effectively manage the implementation and proper utilization of computer based systems in military operations.

— Educate the officer in the fundamentals of systems development in order that he is capable of translating operational requirements into systems specifications.

— Educate the officer in the concepts of economic analysis of computer systems in order to optimize costs and benefits.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus is considered minimal preparation. Students lacking these quantitative prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success such as: GRE (Graduate Record Examination) GMAT (Graduate Management Admission Test) formerly ATGSB (Admission Test for Graduate Schools of Business), indicate a capability for graduate level work.

DESCRIPTION — The Computer Systems curriculum is an interdisciplinary program which integrates mathematics, accounting, economics, computer science, behavioral science, and management techniques into an understanding of the technical management of large computer centers. Program flexibility is available to permit a student to pursue, in depth, a specialization in an area of interest to himself and his Service community. Completion of the computer systems program requires five quarters (1¼ years) or less depending on the student's academic background, experience and ability. Requirements for the Master of Science in Computer Systems Management are met as an included part of the curricular program. In addition, Naval officers

will be awarded the appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Systems curriculum is in September and March; however, on a case basis, students may commence their program in January or July through prior preparation and careful coordination with the Curricular Office.

INTRODUCTORY STUDY — This portion of the curriculum is generally preparatory in nature and some portions of it may be validated by the officer with appropriate experience or academic background. Undergraduate courses in the following areas are offered:

Mathematics for management
Computer management
Individual and group behavior

GRADUATE STUDY — The graduate portion of the program includes courses in the following areas:

Probability and statistics
Operations research
Financial management
Computer hardware and systems
System analysis and design
Computer management
Organization and management
Defense resource allocation

## COMPUTER SCIENCE CURRICULUM
## CURRICULUM NUMBER 368

OBJECTIVE — This program is designed to:

— Provide an officer with the knowledge and skills necessary to specify, evaluate, and manage the design of computer systems.

— Provide technical guidance in applications ranging from basic data processing to sophisticated tactical systems.

— Educate the officer in the analysis and design methodologies appropriate to an understanding of the hardware and software components of complex computer systems.

— Provide the officer with the capability to utilize the modern computer laboratory in the application of computer techniques to research current military problems.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus is considered minimal preparation. Undergraduate majors in applied science or engineering are highly desirable. Students lacking these prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success, such as the Graduate Record Examination, indicate a capability to work in quantitative subjects. Documented practical experience in the computer field will also enhance a candidate's potential for admission.

DESCRIPTION — Computer Science is concerned with the representation, storage and manipulation of data by techniques and devices applicable to a wide variety of problems. This curriculum is an interdisciplinary program integrating mathematics, probability, statistics, operations research, and electronics in addition to computer hardware and software theory and applications. Completion of the Computer Scienc program requires seven academic quarters (1 ¾ years) or less, depending on the student's academic background, experience, and ability. Requirements for the Master of Science in Computer Science are satisfied as part of the curricular programs. In addition, Naval Officers will be awarded the

appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Science curriculum is in September and March; however, on an individual case basis students may commence their program in January and July through prior preparation and careful coordination with the curricular office.

INTRODUCTORY STUDY — This portion of the curriculum is generally preparatory in nature and some portions of it may be validated by the officer with appropriate experience or academic background. Undergraduate courses in the following areas are offered:

- Calculus, linear algebra, finite mathematics
- Introduction to computers and programming
- Fortran and Cobol programming
- Digital machines

GRADUATE STUDY — The graduate portion of the program includes courses in the following areas:

- Applied probability and statistics
- Discrete mathematics
- Operations research
- Numerical analysis
- Structural programming languages
- Information structures
- Operating systems
- Compiler design
- Data base systems
- System design and analysis
- Data processing management

In addition to the graduate courses, one of the following three option areas must be elected:

**Tactical Computer Systems**

- Real time combat systems
- Microcomputers
- Interactive computation systems
- Data communications

**Computer Software**

- Data base systems
- System simulation

- Artificial intelligence
- Program development: structure, design and languages

**Military Data Processing**

- Computer center operations
- Computer based management Information systems
- Defense resource allocation
- Real time information systems

THESIS RESEARCH — Sixteen quarter hours are allocated for thesis research, eight in each of the student's final two quarters of the program. Emphasis is on military applications and research in the computer science field. The thesis subject will be appropriate to the option area selected.

# ELECTRONICS AND COMMUNICATIONS PROGRAMS CURRICULA NUMBERS 590, 595, 600, 620/620CG

**Robert Alexander Persell,Jr.**, Commander, U.S. Navy; Curricular Officer; B.A. Univ. of Virginia, 1961; M.S. in International Affairs, George Washington Univ., 1971; M.S. in Management, Naval Postgraduate School, 1975.

**Robert Denney Strum**, Academic Associate for Electronics/Communications Engineering; B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

**Alan Wayne McMasters**, Academic Associate for Telecommunications Systems; B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

**Alfred William Madison Cooper**, Academic Associate for Electronic Warfare Systems Technology; B.A., Univ. of Dublin, 1955; M.A., 1959, Ph.D., Queen's Univ. of Belfast, 1961.

**Allan Wiley Tulloch**, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., U.S. Naval Academy, 1967;, M.S. in Management, Naval Postgraduate School, 1972.

OBJECTIVE — The Electronics and Communications Programs include curricula designed to satisfy the needs of the service and the interests of the officers in these fields. Successful completion of a curriculum leads to the award of the degree of Master of Science or a higher degree in the principal field. This education permits the officer to address more knowledgeably current and future military problems associated with electronic/communications systems, and expands his base of professional knowledge and technical competence in his subspecialty area. It is designed to enhance performance in all duties throughout a naval career including operational billets, technical management assignments, and the policy making positions.

Within the broad fields of electronics and communications, various option tracks are available after completing the graduate core requirements. Successful completion of the Engineering Electronics or Communications Engineering Curricula leads to an appropriate Navy subspecialty code, and each curriculum includes all requirements for the degree Master of Science in Electrical Engineering. The Electronic Warfare Systems Technology Curriculum results in an Electronic Warfare subspecialty code, and meets requirements for the degree Master of Science in Systems Technology. In the Telecommunications Systems Curriculum, the Communications Systems Technology subspecialty code is earned, and the requirements for the degree Master of Science in Telecommunications Systems Management are met. All curricula provide the officer with a well-rounded knowledge of the scientific principles, technical practices and managerial/analytical skills pertinent to his field of study. The officer's studies also serve to produce a heightened capacity for creative thought and innovative problem solving. The curricula provide lattitude for studies in asso-

ciated areas outside the field of specialization to accommodate the academic background and individual interests of the officer and help him acquire diverse professional knowledge, a new appreciation for continuing education, an added awareness of the many complex elements of problems, and an enhanced personal confidence conducive to productive achievement throughout his naval career.

## ENGINEERING ELECTRONICS CURRICULUM NUMBER 590

OBJECTIVE (SPECIFIC) — To provide officers, through graduate education, with comprehensive scientific and technical knowledge in the field of electronics as applied to Navy systems.

## COMMUNICATIONS ENGINEERING CURRICULUM NUMBER 600

OBJECTIVE (SPECIFIC) — To provide officers, through graduate education, with a comprehensive scientific and technical knowledge in the field of communications engineering as applied to Navy and Defense Command, Control and Communication Systems.

## ELECTRONIC ENGINEERING AND COMMUNICATIONS ENGINEERING CURRICULA NUMBERS 590 AND 600

QUALIFICATIONS FOR ADMISSION — Prior baccalaureate degree including above average grades in differential/integral calculus and general physics. Those lacking in this background may matriculate via the Engineering Science program, or may upgrade their educational opportunities by taking courses off campus through the Continuing Education Program.

Allied officers may enroll in the above curricula subject to exclusion of classified courses as determined by the Chief of Naval Operations.

DESCRIPTION — These curricula are designed to establish a broad background of basic engineering knowledge leading to selected advanced studies in electronic systems, communications, electronic warfare, ship/weapon control systems, information processing or other pertinent areas of professional applicability. Entry may be made in any quarter: September, January, March or July.

The graduate-studies portion of the program is normally of twelve months duration. It is preceded by an introductory core program which is designed to provide a smooth transition from previous studies and experience. For entering students who have a non-engineering background, except as stated in the qualifications above, and who have been absent from academic studies for five or more years, the background studies may be of up to five quarters duration, leading to a complete program duration of twenty-seven months. For students with better entrance qualifications, special review courses and course validations enable them to complete the total program in eighteen, twenty-one or twenty-four months.

Toward the end of their preparatory program, officers are evaluated for academic progress and potential to complete the advanced degree portion of the curriculum. Those

officers who have demonstrated a capability to satisfy academic requirements for the Master of Science degree will continue in the master's program and select an appropriate area of subject specialization and thesis research. Academically superior students may be selected, subject to service needs and approval, for further advanced studies leading to the degree of Electrical Engineer, Doctor of Engineering or Doctor of Philosophy. Those officers who are unable to continue in graduate-level studies will pursue a shortened terminal program beyond the basic core. An appropriate subspecialty code will be granted to the few officers in this category.

## INTRODUCTORY CORE

The structure of each curriculum recognizes that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without some preparation. The Introductory Core provides a sound academic background in mathematics, computer science and technology, physics and electrical engineering. Each student's prior academic transcript will be evaluated for validation of as many of these courses as possible, or for selection of an advanced, accelerated review course to replace a longer sequence of courses in a given area. Validation permits study of greater breadth or depth in graduate studies and can reduce the time on board required to fulfill subspecialty code and degree requirements. The courses which are not validated will be programmed using a nominal course load for 16-18 credit hours per quarter.

Subjects covered in the core courses include:

- Calculus and vector analysis
- Matrix algebra
- Differential equations
- Complex variables
- Physics
- Circuit theory
- Controls systems
- Electronics engineering fundamentals
- Pulse and digital circuits
- Computer programming
- Digital machines
- Electromagnetic wave theory and engineering
- Communication theory and circuits

## GRADUATE STUDY

The advanced studies program leading to a master's degree is individually designed to be academically sound, consistent with the needs of the service and responsive to the interests and objectives of the officer. The program consists of courses in required subject areas, elective courses in coherent and relevant option areas and thesis research. Classroom work is supplemented by an active seminar series in which military and industrial leaders provide an operationally relevant perspective on current topics of interest. The degree requirements include completion of the requirements for the degree Bachelor of Science in Electrical Engineering and completion of 40 credit hours of approved graduate study. The additional thesis research normally occupies the time equivalent for four courses, allocated during the final three quarters of the program. Any transfer of graduate credit which is applicable will allow an opportunity in an officer's program for additional electives.

Upon successful completion of an approved curriculum, officers will be awarded an appropriate subspecialty billet code. On-going counseling is provided by the Curricular Officer/ Academic Associate team for all officer students, and a close professional relationship between officer students and faculty enhances professional and career development.

### The Graduate Core

To provide a well rounded graduate program, all students are required to include courses in the subject areas of advanced electronics, signal processing, stochastic processes and advanced systems.

**Option Electives**

The graduate program also requires a cohesive sequence in two of the selected areas listed below. Latitude is permitted in specific elective selections, with the choices being approved consistent with overall professional applicability and soundness of academic requirements.

Communications
Lasers, electronic-optics and solid state electronics
Control systems, guidance and navigation
Digital systems and computers
Electromagnetics and microwaves
Military systems

## ELECTRICAL ENGINEER

As determined by service needs and superior academic achievement, officers may matriculate into a program leading to the advanced degree Electrical Engineer. This advanced graduate program requires approximately seven quarters of work beyond the Introductory Core. The scope of graduate study is greatly increased over the Master of Science curriculum and a thesis of greater depth is required. In addition, the officer may be provided an opportunity for an industrial experience tour of up to 12 weeks duration.

## ELECTRONIC WARFARE SYSTEMS TECHNOLOGY CURRICULUM NUMBER 595

OBJECTIVE (SPECIFIC) — To provide the service with sufficient officers thoroughly knowledgeable in the technical and operational aspects of both the art and the role of Electronic Warfare as a vital, integral part of modern warfare.

QUALIFICATIONS FOR ADMISSION — This curriculum is open only to officers of the U.S. Armed Forces. Admission to the curriculum requires a baccalaureate degree with above average grades. Completion of mathematics through differential and integral calculus is required. Students lacking this background may matriculate via the Engineering Science Program. Although designed primarily for unrestricted line officers with established warfare qualifications, quotas may be available on a case basis for officers of the restricted line communities. Of importance equal to academic qualifications is demonstrated outstanding performance in an officer's warfare specialty. A tour of duty providing operational electronic warfare experience is also desirable but not mandatory. Officers selected for the 595 Curriculum must be eligible for security clearance permitting access to sensitive intelligence information.

DESCRIPTION — This curriculum is designed to provide an understanding of the principles underlying the broad field of electronic warfare. Because of the electronic nature of modern sensor, weapon and command, control and communication systems, this curriculum seeks to develop in the officer a grasp of electronic, electrical and electromagnetic fundamentals, theory and techniques. Another principal goal of the 595 Curriculum is to develop an ability to describe technological factors in terms which are meaningful and supportive in an operational or tactical situation. To achieve these aims, preparatory material in mathematics, operations research, probability, statistics, physics and computer science are included in the program.

The 595 Curriculum is highly

interdisciplinary and comprises several tracks. Inputs will occur annually in March. Each officer's transcript of prior baccalaureate study is evaluated to eliminate unnecessary duplication of previously covered material.

### INTRODUCTORY CORE

This portion of the program provides a sound academic background in mathematics, computer science and technology, physics and electrical engineering. Each student's prior academic transcripts will be evaluated for validation of as many of these courses as possible. The courses which are not validated will be programmed using a nominal course load of 16-18 credit hours per quarter.

Subjects covered in the core courses include:

- Calculus and vector calculus
- Ordinary differential equations and LaPlace Transforms
- Fourier analysis and partial differential equations
- Probability theory
- Physics
- Electro-optics fundamentals
- Computer programming
- Real time combat direction systems
- Naval warfare and national security
- Electronic systems
- Signals and noise
- Pulse and digital circuits
- Control systems
- Electromagnetic theory
- Decision analysis and data analysis
- Simulation and war gaming
- Meteorology

### GRADUATE STUDY

The Operational Electronic Warfare Curriculum qualifies the student for the degree Master of Science in Systems Technology. During the last three quarters of this eight-quarter (two-year) program the officer undertakes thesis research and preparation on a topic relevant to current military electronic warfare efforts. A program of seminars given by representatives of EW-oriented activities and industry supplements classroom instruction.

- Microwave devices and radar
- Signal processing systems
- Electromagnetic radiation, scattering and propagation
- Electronic warfare systems
- Electro-optics
- Human vigilance performance
- Operations analysis
- Operational test and evaluation
- EW computer applications
- SIGINT and threat environment
- Underwater sound, systems and countermeasures
- Communications in organizations

## TELECOMMUNICATIONS SYSTEMS CURRICULA NUMBERS 620 AND 620CG

OBJECTIVE (SPECIFIC) — To provide instruction to officers who will perform as Communications Managers of new communications systems applications or as Communications Officers in large commands and staffs, afloat and ashore, including the organization of the Joint Chiefs of Staff and the Defense Communications Agency.

QUALIFICATIONS FOR ADMISSION — Admission to the curricula requires a baccalaureate degree with above average grades. Completion of mathematics through college algebra and trigonometry is required for the 620 curriculum. The qualifications for the 620CG curriculum are the same as the 590 and 600 curricula. The student must be ready to start calculus courses on enrollment.

DESCRIPTION — The 620 and 620CG curricula are sponsored respectively by the Director, Naval

Communications and U.S. Coast Guard Headquarters. Each curriculum provides comprehensive study in management, with emphasis upon the systems management field. Additionally, the curricula provide study in the technical field appropriate to decision making in advanced systems and program management. These technical courses within the 620 curriculum have been especially prepared for non-engineers whereas those in the 620CG curriculum are engineering courses. Classroom instruction is supplemented by guest lecturer seminars which afford the student an opportunity to hear discussions of communications topics by military officers and civilian executives from the Naval Telecommunications Command, Defense Communications Agency, National Security Agency and other major communications activities.

The 620 classes convene in September. Officers whose undergraduate transcripts indicate a strong background in mathematics through calculus may, on a case basis, enter a quarter early in July or a quarter late in January. Students are accepted for the 620CG curriculum in either October or March. Each student's prior academic transcript is evaluated for validation of courses or for transfer of credit to cover as many courses as possible. Validation is also encouraged for courses whose content has been acquired by experience or service courses. The curricula are interdisciplinary in nature because of the wide knowledge required of the graduate. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. It is required that each student follow a program of graduate level study which will yield 40 credit hours in Administrative Sciences and Quantitative Methods and 16 credit hours in Communications Systems and Computer Science. Successful completion of the program leads to the degree Master of Science in Telecommunications Systems Management. Representative course titles for the core are listed below:

**620 (Navy) Curriculum**

- Calculus and matrix algebra
- Differential equations
- Probability and statistics
- Operations research
- Electronics systems
- Communications systems
- Signal transmission systems
- Communications systems analysis
- Financial and managerial accounting
- Managerial economics
- Defense resource allocation
- Economics of communications systems
- Individual and group behavior
- Organizational theory
- Procurement and contract administration
- C3 mission and organization
- Personnel management and labor relations
- Naval telecommunications and management
- Computer programming
- Real time interactive computer systems
- Real time information systems management

**620CG (Coast Guard) Curriculum**

- Calculus and matrix algebra
- Differential equations
- Complex variables
- Applied probability theory
- Operations research
- Linear programming
- Networks flows and graphs
- Basic circuit theory
- Circuit theory
- Electronics fundamentals
- Communications theory
- Electromagnetic theory

Digital communications
Electromagnetic radiation and compatibility
Statistical communication theory
Financial and managerial accounting
Managerial economics
Defense resource allocation
Individual and group behavior
Organization and management
Procurement and contract administration
Computer programming
Structure of digital computers
Real time interactive computer systems
Real time information system management
Computer based management information systems
Leadership and group behavior
Management policy
Procurement policy
Internal audit and control
Economics of computers
Communications satellite systems engineering

## ENGINEERING SCIENCE PROGRAM

OBJECTIVE — To provide officers who desire and are selected for an advanced technical education, but who are deficient in mathematics and the physical sciences, an opportunity to qualify for admission into one of the graduate level technical programs at Naval Postgraduate School.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with a C + average, completion of at least two pre calculus mathematics courses with a B average, or at least one course in calculus with a C grade and at least one course in physics.

DESCRIPTION — Officers ordered to this preparatory program are assigned to the curricular office of the graduate curriculum they have been selected to attend. Each officer selects courses to correct his personal deficiencies, concentrating on basic mathematics, physical science and courses in the preparatory part of his graduate curriculum.

Normal input to the curriculum occurs in March and September, with a planned duration of two quarters. Inputs can be accepted at other dates dependent on the starting dates for the graduate curriculum to be followed.

# ENVIRONMENTAL SCIENCES PROGRAMS CURRICULA NUMBERS 372, 373, 440

**Lanny Alan Yeske, Commander,** U.S. Navy; Curricular Officer; B.S., Univ. of Nebraska, 1960; M.S. in Oceanography, Naval Postgraduate School, 1968; Ph.D., Univ. of Wisconsin, 1973.

**Robert George Paquette,** Academic Associate (Oceanography); B.S., Univ. of Washington, 1936; Ph.D, 1942.

**Robert Joseph Renard,** Academic Associate (Meteorology); M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

## METEOROLOGY CURRICULUM CURRICULUM NUMBER 372

OBJECTIVE — To provide qualified personnel with a sound understanding of the science of meteorology and to develop the technical expertise to provide, and utilize, meteorological and oceanographic data in support of all aspects of military operations.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments, and policy making positions. Personnel will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their professional career.

QUALIFICATIONS FOR ADMISSION* — A baccalaureate degree with at least average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus and one year of college physics is considered to be minimal preparation.

**This curriculum is not open to U.S. naval officers. The program is open to Air Force Officers, Allied Officers, and qualified federal employees.*

DESCRIPTION — The Meteorology Curriculum is interdisciplinary in nature and encompasses those areas of meteorology which are directly related to environmental support of operations. The program consists of preparatory subjects, a sequence in synoptic and numerical meteorology, and a sequence of courses in dynamic meteorological processes. The program recognizes the interaction of the atmosphere and the ocean mass and deals with their relationships at the air/sea interface.

Classroom instruction is supplemented by laboratory exercises, computer solutions to problems, and guest lecturers and seminars. Upon completion of the program, the student is qualified to serve independently as a meteorological forecaster. By completing a required thesis, he is introduced to the problems associated with independent research. Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology.

Matriculation may occur any quarter each year. Although the program is designed for eight academic quarters, students qualified may have this period shortened by validation of courses previously taken, transfer of credits from other institutions, and by evaluation of the level of previous experience in the field.

### INTRODUCTORY STUDY

Preparatory courses are chosen as necessary to provide the academic prerequisites for successful pursuit of the graduate courses. The first courses are typically in the following areas:

- Linear algebra and vector analysis
- Differential equations
- Partial differential equations
- Numerical analysis
- Numerical methods for partial differential equations
- Introductory to meteorology

### GRADUATE CORE

After satisfaction of preparatory requirements, the student is capable of entering the graduate phase of the curriculum, which consists of course sequences in the following areas:

DYNAMIC AND PHYSICAL METEOROLOGY SEQUENCE: Provides the student with the knowledge required to make applications of meteorology to current and future civil and military endeavors and to the design of environmental support systems.

- Geophysical thermodynamics
- Introductory geophysical fluid dynamics
- Heat transfer processes
- Dynamic meteorology
- Air/Sea interaction
- Cloud physics and atmospheric pollution

METEOROLOGY ANALYSIS AND FORECASTING SEQUENCE: Assists students to develop the skills required to serve as a meteorological forecaster.

- Advanced climatology
- Meteorological analysis
- Tropospheric and stratospheric meteorology
- Tropical meteorology
- Weather forecasting
- Numerical weather prediction
- Polar meteorology
- Mesoscale meteorology

Ample time is provided for students to complete research for a thesis in the area of their primary interest. Elective courses are also available to further their knowledge in specific meteorological topics or in the areas of oceanography, computer science, or operations research.

## AIR-OCEAN SCIENCE CURRICULUM CURRICULUM NUMBER 373

OBJECTIVE — To provide qualified personnel with a thorough understanding of the air-sea environment and to develop the technical expertise to provide and utilize meteorological and oceanographic data and knowledge in support of all aspects of military operation.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their careers.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree in meteorology, or oceanography, or the equivalent. Provision is made for lesser qualified students to enter via the Oceanography Curriculum (#440). While this curriculum is open

to officers of the other U.S. military services, allied officers, and U.S. federal employees, its availability to U.S. Navy officers is limited to those of the Restricted Line (Special Duty — Geophysics). Additionally, Navy officer students in the Oceanography Curriculum may, upon change of designator, transfer into the Air-Ocean Science Curriculum.

DESCRIPTION — The Air-Ocean Curriculum (#373) is interdisciplinary in nature and encompasses those areas of meteorology and oceanography which are directly related to environmental support of military operations. The program consists of preparatory subjects, basic courses in dynamic and physical meteorology and oceanography, and a sequence in environmental analysis and forecasting, including numerical methods by computer. The program recognizes the importance of interactions between the atmosphere and the oceans, and deals with their relationships at the air/sea interface.

Classroom instruction is supplemented by laboratory exercises, field experience, computer solutions to problems, and guest lectures and seminars. Each student is required to complete a satisfactory thesis. In so doing the student is introduced to the problem of applying his theoretical knowledge to the solution of a practical problem. Upon completion of the program, the student is qualified to serve independently as a meteorological and oceanographic forecaster in support of operations.

Matriculation may occur any quarter each year. A typical program for students with a baccalaureate degree in either meteorology or oceanography is eight quarters. However, students may have this period shortened by validation of courses previously taken, transfer of credits, and by evaluation of the level of previous experience in the field.

Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology and Oceanography.

### INTRODUCTORY STUDY

Preparatory courses are chosen as necessary to provide the academic prerequisites for successful pursuit of the graduate courses. Some of these prerequisites are:

- Linear algebra
- Vector analysis
- Differential equations
- Partial differential equations
- Numerical analysis
- Numerical methods for partial differential equations
- Introductory meteorology and oceanography
- Principles of measurement of the environment
- Geophysical thermodynamics
- Geological, biological and chemical oceanography
- FORTRAN programming
- Probability and statistics

### GRADUATE CORE

After satisfaction of preparatory requirements, the student is capable of entering the graduate phase of the curriculum, which includes the following:

**Dynamic and physical Meteorology and Oceanography Sequence:** Provides the student with the knowledge required to make applications of meteorology and oceanography to current and future military hardware and software, and to the design of environmental support systems. Areas covered are:

- Geophysical fluid dynamics
- Heat transfer process
- Dynamic meteorology
- Dynamic oceanography
- Air/Sea interaction
- Random processes

**Meteorological and Oceanographic Analysis and Forecasting Sequence:** Assists students to

develop the skills required to serve as an environmental forecaster. Areas covered are:

- Introduction to environmental analysis
- Climatology
- Descriptive physical oceanography
- Meteorological analysis
- Tropospheric and stratospheric meteorology
- Tropical meteorology
- Weather prediction
- Numerical prediction
- Environmental support for naval operations
- Sound in the ocean
- Acoustical forecasting
- Ocean wave and surf forecasting

Ample time is provided for students to complete research for a thesis in the area of primary interest. Elective courses are also available to further knowledge in specific meteorological and oceanographic topics or in such areas as operations analysis, computer science, management, electronic, advanced mathematics and international law and ocean policy.

## OCEANOGRAPHY CURRICULUM CURRICULUM NUMBER 440

OBJECTIVE — To provide students with a sound understanding of the science of physical oceanography, and to develop the technical expertise to provide and utilize oceanographic and acoustical data in support of all aspects of military operations. Particular emphasis is placed on the understanding of oceanographic environmental effects on the solution of the Antisubmarine and Undersea Warfare problems.

Students who successfully complete their curriculum will be awarded an appropriate subspecialty billet code. However, this education enhances performance in all duties throughout a military career including operational billets, technical management assignments, and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their career.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with at least average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry is considered to be minimal preparation.

DESCRIPTION — The Oceanography Curriculum #440 is interdisciplinary in nature and encompasses a broad spectrum of physical, chemical, biological, and geological oceanography support of military operations.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. The Research Vessel ACANIA is available for class laboratory experience as well as for individual research efforts. Guest lectures, seminars, and in situ study at the Naval Arctic Research Laboratory in Barrow, Alaska, serve to round out the curriculum. Each student is required to complete a satisfactory thesis. In so doing the officer is introduced to the concept of applying theoretical knowledge toward a practical application. Successful completion of this pro-

gram leads to the awarding of the degree of master of Science in Oceanography and qualifies the student to serve in any of the oceanoggraphy billets in the Department of Defense.

Matriculation may occur any quarter of the year. Although the program is designed for eight quarters, qualified students may have this period shortened by validation of courses previously taken, transfer of credits from other institutions, and by evaluation of the level of previous experience in the field.

### INTRODUCTORY STUDY

Preparatory courses are chosen as necessary to prepare students for graduate level work. These first courses are in the following areas:

- Descriptive physical oceanography
- Linear algebra and vector analysis
- Differential equations
- Computer programming with FORTRAN
- Marine meteorology for oceanographers

### GRADUATE CORE OCEANOGRAPHY

The heart of the oceanography program consists of a basic core of graduate level courses supplemented by available electives. The knowledge of principles gained in these studies will enable the student to make beneficial applications of oceanography to future military hardware design, military tactics and strategy. Typically included are courses in:

- Partial differential equations and integral transforms
- Numerical analysis
- Geophysical random processes
- Descriptive physical oceanography
- Geological oceanography
- Biological oceanography
- Chemical oceanography
- Scientific cruise experience
- Waves and tides
- Coastal oceanography
- Geophysical fluid dynamics
- Ocean dynamics
- Sea/Air interaction
- Seminar in oceanography

Courses Directed Specifically to Military Applications:

- Physics of sound in the ocean
- Sound in the ocean and acoustic models
- Principles of measurement
- Marine geophysics
- Polar oceanography
- Acoustic forecasting
- Ocean wave forecasting
- Tactical environmental products
- Regional military oceanography

### GRADUATE CORE HYDROGRAPHY

The oceanography student may choose to pursue studies in hydrography as a program option. Course work in the basic oceanography core is supplemented/replaced with study in the following areas:

- Basic hydrography
- Geodesy
- Hydrographic measurements
- Hydrographic operations
- Hydrographic cruise
- Photogrammetry
- Cartography

Ample time is provided for students to complete research for a thesis in the area of primary interest. Elective courses are available to further knowledge in specific oceanographic topics or in such areas as operational analysis, computer science, management, meteorology and international law and ocean policy.

# NAVAL ENGINEERING PROGRAM CURRICULA NUMBER 570

**George Purviance Neyman, III**, Commander U.S. Navy; Curricular Officer; B.S., Capitol Univ., 1957; B.S., Webb Institute of Naval Architecture, 1966; M.S., 1966; M.S., Univ. of Rhode Island, 1972.

**Matthew Dennis Kelleher**, Academic Associate; B.S., Univ. of Notre Dame, 1961; M.S.E.E., 1963; Ph.D., 1966.

## NAVAL ENGINEERING CURRICULUM CURRICULUM NUMBER 570

OBJECTIVES — To provide graduate education, primarily in the field of Mechanical Engineering, to officers from all communities. The graduate will have the technical competence to operate and maintain modern warships and weapons systems. He will be able to participate in technical aspects of naval systems acquisition and able to recognize applications for technological advances in naval ships and weapons. Through emphasis on the design aspect in the program, the graduate will be well prepared to apply these advances in technology to the warships of the future.

ENTRANCE DATES — Classes normally convene any quarter; however, April and September are preferable for more effective program scheduling.

QUALIFICATION FOR ADMISSION — A baccalaureate degree or its equivalent, preferably in engineering or the physical sciences, is required. Mathematics through integral calculus plus one year of physics are non-waiverable requirements. One year of chemistry at the college level is highly desirable but not mandatory. The Engineering Science program (Curriculum Number 460) is available for candidates who do not meet all admission requirements. The additional time required will vary with the candidate's background.

DESCRIPTION — The academic program is grouped into an introductory study portion and an advanced graduate level study portion. The introductory study program consists of undergraduate and graduate level courses which provide the necessary breadth and depth for successful pursuit of the advanced graduate level study portion of the program. Each student's transcript is evaluated for validation of as many of the introductory study courses as possible and the student is interviewed upon arrival to reach a final decision on those courses to be programmed for the introductory study program. This portion of the curriculum includes courses in the following areas:

**Undergraduate Introductory Study:**

Calculus review
Linear algebra and vector analysis
Computer Programming
Ordinary and partial differential equation/ complex functions
Engineering materials
Statics and dynamics
Mechanics of solids
Engineering thermodynamics
Fluid mechanics
Electrical engineering fundamentals

**Graduate Introductory Study:**

Advanced mechanics of solids
Mechanical vibrations
Marine power systems
Survey of nuclear power systems

Applied mechanics of naval and ocean structures
Design of machine elements
Marine gas turbines
Engineering numerical analysis
Properties of structural materials
Probability and statistics

**Advanced Graduate Study:**

After completion of the introductory study portion of the program, a meaningful set of electives are selected from the advanced graduate level courses. These are chosen in consultation with the Curricular Officer and faculty advisors. A normal program of study leading to the degree Master of Science in Mechanical Engineering will allow for five such elective courses chosen from the following extensive list:

FLUID MECHANICS OPTION
- Viscous flow
- Fluid machinery
- Fluid power control
- Naval hydrodynamics
- Advanced applied mechanics of naval and ocean structures

HEAT TRANSFER OPTION
- Conduction and radiation
- Convection
- Advanced topics in fluid dynamics and heat transfer
- Applications of heat transfer

MARINE/WEAPONS ENGINEERING OPTION
- Marine propulsion control systems
- Marine vehicle design
- Marine engineering design
- Naval weapons: guns, missiles and lasers

MATERIALS SCIENCE OPTION
- Corrosion in the marine environment
- Microscopy
- Phase transformation
- Advanced engineering materials

NUCLEAR ENGINEERING OPTION
- Nuclear measurements lab
- Nuclear reactor analysis
- Reactor engineering principles and design

SOLID MECHANICS OPTION
- Advanced mechanics of solids
- Finite element methods
- Theory of continuous media
- Advanced vibrations
- Advanced dynamics

Availability of a graduate course may be dependent on study loading at the time the course is desired. In special cases, an advanced topics program in the subject area of interest may be arranged between the professor and student.

THESIS — An original research project resulting in a finished thesis is an integral part of the curriculum. The schedule of classes is arranged to provide time during the final two quarters for concentration in this area of specialization. Topics are selected in the fifth quarter of the students program for approval by the Chairman, Department of Mechanical Engineering. A faculty advisor is assigned for consultation in designing and conducting a program of research. Considerable emphasis is placed on the production of a quality thesis.

ADVANCED DEGREES — The Naval Engineering program is designed to lead to the degree of Master of Science in Mechanical Engineering. A limited number of particularly well qualified students may be able to further their education beyond the master's level and seek the degree of Mechanical Engineer. Additional courses are chosen from the list of graduate options and a thesis of greater scope and depth is required. Approximately three additional quarters are necessary to complete the requirements for the Mechanical Engineer degree. Criteria for selection include superior academic performance, tour availability, and a demonstrated capability to perform in the environment of the professional engineer. A program leading to the Doctor of Engineering or the Doctor of Philosophy degree can also be made available to the truly outstanding student who can qualify as a candidate for this most demanding course of study. The principle governing factor in the availability of a doctoral study opportunity is the requirement of the Navy to meet billet requirements at the time of application.

SUBSPECIALTY CODE — Those officers successfully completing these programs will be identified as subspecialtists in accordance with the current Bureau of Naval Personnel Instructions.

# NAVAL INTELLIGENCE/ NATIONAL SECURITY AFFAIRS PROGRAMS CURRICULA NUMBERS 681, 682, 683, 684, 686 AND 825

**Richard John Schlaff**, Commander, U.S. Navy; Curricular Officer, B.A., Michigan State Univ., 1959; M.B.A., Univ. of Denver, 1965.

**James Herbert Johnson** Lieutenant Commander U.S. Navy; Assistant Curricular Officer for the Naval Intelligence Program; B.S., U.S. Naval Academy, 1967.

**Willian Reese**, Academic Associate for Naval Intelligence; B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

**Stephen Jurika**, Academic Associate for National Security Affairs; B.S., U.S. Naval Academy, 1933; M.A., George Washington Univ., 1957; Ph.D., Stanford Univ., 1962.

## NAVAL INTELLIGENCE CURRICULUM CURRICULUM NUMBER 825

OBJECTIVES — Objectives of the curriculum are to provide the students with advanced education in the following areas:

(1) the security interests of the United States and other major countries, with particular emphasis on the military, economic, political, and social factors which shape and affect their interests and capabilities;

(2) the vocabulary, resource material, and basis of operation of military systems and subsystems which allow the incorporation of technical and environmental information into the solution of intelligence problems;

(3) an understanding of the strengths and weaknesses of current military systems (U.S. and U.S.S.R.) and areas of probable improvement within the next 10 to 15 years;

(4) methods of analysis applicable to the intelligence process, with particular emphasis upon forecasting and threat assessment;

(5) problems in the administration and dissemination of intelligence information, and the management of the intelligence process;

(6) techniques of interpersonal and group communication.

QUALIFICATIONS FOR ADMISSION — U.S. officer or federal government civilians. A college degree with a B average and college algebra or its equivalent and demonstrated excellence in a warfare or restricted line specialty. All officers selected must be eligible for Special Intelligence access. Recipients of orders not having a current Special Background Investigation (SBI) (within four and one half years), must submit the required request forms expeditiously in accordance with their PCS orders.

DESCRIPTION — The Naval Intelligence Curriculum is an interdisciplinary program which integrates political, science, mathematics, management, operations analysis, oceanography, meteorology, electrical engineering, physics, computer science and economics into an understanding of Naval Intelligence.

Those students that can validate specific core courses are permitted

to concentrate in greater depth in a certain area or to choose electives from other areas that will broaden their background. Two electives in the fifth and sixth quarters are allowed for all students. Many students select courses that relate directly to their thesis research effort to provide the opportunity for the further acquisition of skills, methodologies, and knowledge in this area. Each student's program must be approved by the Curricular Office.

An original research project resulting in an acceptable thesis is an integral part of the curriculum. Research efforts are directly supported by the ingelligence community and include a tour of up to two weeks with intelligence and other government agencies. A guest lecture and seminar program serves to keep the student abreast of current developments in naval intelligence.

Students in the Naval Intelligence Curriculum will, in general, pursue the following course sequences: (1) Defense Technology, (2) National Security Affairs, and (3) Analytical and Management.

The Defense Technology sequence is designed to address the special problems of technical intelligence, emphasizing technical literacy and the ability to communicate concerning technological and environmental problems. The sequence seeks to provide the perspective that will assist assessment of the reliability and significance of technical and environmental data, as well as ensure familiarity with the resources in these fields that may be applied to intelligence problems. New technological developments, weapon system acquisition, and technological forecasting are pursued through student participation in seminars and practical exercise situations. Sample topics contained in this sequence include the following:

- Environmental data networks
- Electromagnetic and acoustic wave propagation
- Acoustic surveillance concepts and systems
- Radar systems: observables and ELINT, capabilities and system options, components
- Optical systems: visual and infra-red
- Communications theory: spectral analysis, modems and systems
- Control systems: concepts and components
- SIGINT systems
- Strategic systems
- Technical threat analysis
- Technological forecasting
- Technical developments in C3 and intelligence

The National Security Affairs sequence delineates the interface between international politics, defense resource management and weapons technology. The courses in this sequence emphasizes both American national security affairs and area studies. Sample topics include the following:

- Use of systems theory to explain international events and trends
- Foreign policy and crisis decision making
- Defense policy objectives and strategy
- U.S./Soviet net assessment
- Dynamics of Soviet decision making
- Soviet naval warfare capabilities
- Problems of industrialization, revolution and conflict in East Asian states
- Naval capabilities and strategies of Asian states

The Analytical and Management sequence introduces the student to quantitative techniques, substantive research methods, and the primary concepts of resource management. It provides a methodological survey of various means to structure given problems, formulate possible solutions, organize and compile the supporting data, assess the reliability and communicate the significance of the results obtained. Sample topics include the following:

- Common transcendental functions
- Differential and integral calculus
- Probability and statistics

Public personnel administration
Public sector resource management
Data base management systems
Research design and measurement
Content and events data analysis
Decision analysis
Project management
Campaign analysis
Quantitative assessment of military capabilities
Intelligence measurement methods
Methodological case studies
Analysis of Soviety naval operations

## NATIONAL SECURITY AFFAIRS CURRICULA NUMBERS 681, 682, 683 684, AND 686

OBJECTIVE — These curricula are designed to provide graduate education to officers and DOD civilians emphasizing the following areas: politico-military affairs, strategic and operational planning, attache affairs, foreign intelligence and area analysis. These curricula may be divided into area specialties (681, 682 and 683 — delivered in cooperation with the Defense Language Institute (DLI), also in Monterey) and functional specialties (684 and 686) conducted entirely at the Postgraduate School. Successful completion of any of these curricula leads to the degree of Master of Arts in National Security Affairs.

Specific educational objectives related to these curricula are:

(1) *Geopolitics* — Students will be familiar with the geopolitical regions of the world in terms of their global strategic importance. They will understand how geography, climate, economics, and demography influence political thought and foreign policy.

(2) *Strategic Posture* — Students will know the national strengths and weaknesses which affect strategic posture and capabilities. They should be able to assess major military, political, economic, and sociological trends as they relate to policy choices in domestic and foreign affairs.

(3) *Military Forces* — Students will understand the role, political influence, social position, composition, structure, capabilities, and vulnerabilities of the armed forces. They should be familiar with current political and military developments. They should be familiar with regional military and political relations and regional defense agreements both bilateral and multilateral.

(4) *Geography* — Students will have knowledge of geography and its influence on national development, domestic transportation, economic and military posture. Area specialists should have a more detailed geographical knowledge of their areas and the strategic significance of their specific regions.

(5) *Economics* — Students will be aware of the economic strengths and weaknesses of the major power blocs of the world, as well as economic phenomena which influence ideology, military doctrine, industrial and social development. Area specialists must be familiar with their respective region's principal resources and economic influence in the world, as well as their region's industrial capacity.

(6) *Politics* — Students will have a knowledge of the major types of political systems and governmental organizations. They should be aware of current political doctrine and issues. They should know the strength, appeal and influence of Communism and other ideologies. Area specialists should have a more detailed knowledge of their area and be aware of the current relation-

ships and attitudes toward both the United States and the Soviet Union prevalent in it.

(7) *Historical Development* — The student should understand the historical trends and influences that have shaped and provide the context for interaction in today's international environment and future developments. Area specialists should acquire detailed knowledge concerning the historical developments in the region of their specialty with particular emphasis on the political evolution, traditional enemies and conflicts, regional alliances, and domestic issues.

(8) *Culture and Religion* — The student will be familiar with the influence of class structure, cultural and religious values, and ideology on domestic and foreign affairs. They should understand the origins and present state of cultural and religious differences and conflicts and how these differences affect regional and national cohesiveness.

(9) *Current Issues* — Student will be familiar with the major security issues in the world today. These include, but are not limited to political and military conflicts, insurgencies, social problems and efforts for social reform, economic problems and other issues which affect both the status or well-being of the nations of the world. Knowledge of these issues should be related to the formulation and implementation of U.S. foreign and security policy.

(10) *Analytical and Research Skills* — Scholarly skills emphasized throughout the program include: effective oral and written expression, techniques of research, interpretation and evaluation of complex data, problem solving, forecasting, decision making, the process of negotiation and debate, the formulation of strategy and politico-military objectives.

(11) *Language* — Area specialists should be capable of maintaining their expertise by continuing study in the given professional area. This would include the reading of newspapers and journals written in the language of the area in order to be cognizant of developments as they occur. The ideal area specialist should have intensive language training in one major language group and acquire working knowledge of a second language in his specialty area.

QUALIFICATIONS FOR ADMISSION — Officers and civilians of the U.S. Government. The entrance requirements for these programs are a baccalaureate degree earned with above average academic performance. Applicants may demonstrate their aptitude for the specific curriculum concerned through undergraduate courses that meet program prerequisites, Graduate Record Examination results, or other evidences. Applicants must have the approval of the Chairman, Department of National Security Affairs.

### AREA SPECIALTY CURRICULA

#681 — Middle East, Africa, South Asia
#682 — Far East, Southeast Asia, Pacific
#683 — Europe, USSR

DESCRIPTION — These curricula are cooperative programs with the Defense Language Institute. They last from one to two years depending upon the curricula and option selected, the language studied, and previous educational background. Inputs can be accepted to these programs each quarter of

the academic year (July, September, January or March). Officers are assigned to NPS for the full duration of the combined program. Quotas for the language instruction are obtained directly from DLI by the Curricular Office, except in the case of those students who have acquired language proficiency either at DLI or other institutions prior to these admission to the program.

Student programs are individually tailored. Course selection depends upon an officer's academic and professional background, sponsor requirements, and area specialty concerned. Course mix and sequence will also vary according to the quarter of entry. Each of the three curricula is built upon a common core of approximately six courses.

### Common Core

The common core provides a foundation for each student in the methodological approaches to analysis of the international environment, major specific affairs issues applicable to all regions of the world, and the conduct of U.S. security affairs. Topics covered include the following:

- Conceptual framework for understanding comparative politics
- Theories of political development and change
- Research design
- Modeling factors of interstate behavior and national decision making
- World trade and the international monetary system
- Location and flow of strategic resources
- Cross-national security assistance including arms and technology transfer
- Defense decision making process
- Executive/legislative interaction and influence
- International perspectives of American civilization

### #681 — Middle East, Africa, South Asia

Individual programs in this curriculum emphasize area studies focused on one of the three subregions in this program or contain a blend of courses applicable to all three subregions. Courses in the following areas are offered:

- Impact of geographic and oceanographic environment on military campaigns
- Communications, natural resources, and environmental factors — their impact on the African continent
- Religious and social systems of Southern Asia
- The Arabic, Judaic, Turkish and Persian traditions
- Interplay of political and social forces within the Middle East
- Internal African policies and their impact on U.S. security interests
- Soviety interests and naval expansion in the Indian Ocean
- The changing importance of Middle East oil in the world supply of energy
- Strategic problems of access to and defense of the Mediterranean littoral
- Strategic resources as determinants in great power involvement on the African continent

### #682 — Far East, Southeast Asia, Pacific

Individual programs consists of a blend of courses applicable to all three of these subregions. Courses dealing with the Soviet Union, a Eurasian power and major actor throughout Asia, are included in all options. Courses in the following areas are offered:

- Historical forces relevant to modern revolutionary movements
- The great Asian religions and their role in the development of social systems
- The role of ethnic minorities and the influence of the overseas Chinese
- The transformation of Indo-China into communist states
- Present and future military capabilities and strategies of Asian states
- Nationalism, modernization and security in the governments of South Asia
- Crisis management and trends in Soviet foreign policy
- Forecasting international conflict in Asia
- The extent and influence of Sino-Soviet relations on other nations

### #683 — Europe, USSR

Individual programs emphasize area studies focused on these subregions. Courses in the following areas are offered:

- Nuclear proliferation technology and politics
- Deterrence theory and practice
- Elements of strategic geography: the political, economic, social and military applications
- The polarization of Europe into two security systems: NATO and the Warsaw Pact
- Domestic factors conditioning Soviet national security policy
- Doctrinal and functional analysis of Soviet naval strategy
- Pattern of Communist takeovers and system development
- Strategic problems of access to and defense of the Mediterranean littoral
- Current issues in Soviet-European affairs

## FUNCTIONAL SPECIALTY CURRICULA

### #684 — International Organizations and Negotiations

This curriculum focuses on the bi- and multilateral security relationships between the United States and other nation states, its interests and include the organization and structure through which such relationships are conducted and the development of international institutions and policies that provide guidelines for such interaction such as international law, the law of war, the law of the sea. Some continuing emphasis beyond core studies on U.S. national security affairs is also included. Courses in the following areas are offered:

- The legal reasoning and source materials employed in international law
- Case studies of international organizations: their utility and limitations
- American goals, objectives and resources applicable to bi- and multi-lateral relationships
- Concepts and technical aspects of the formation of a rational ocean policy
- Utility and limitations of models used in the policy sciences for analyzing the defense policy process
- Oceanographic, military, political and legal problems of the oceans
- Arms control and disarmament
- Soviet political institutions and economic structures
- Demilitarization of the Indian Ocean
- Viewpoint of both oil exporting and oil importing countries
- Alliances, bases and security systems in Asia

### #686 — Strategic Planning

This curriculum focuses on major issues and U.S. security affairs with equal emphasis. The major thrust is the evolution of military capabilities, force employment and contingency situations. Courses in the following areas are offered:

- Prerequisites for analysis of defense budgets
- Pattern analysis of terrorist activities
- Technology and political influences of nuclear weapons
- Factors dominating the arms transfer policies of the major powers
- Impact of arms transfers on regional conflict and economic development
- Strategic context of American national security policy
- The role of OMB, and NSC and the Presidential Staff
- Forecasting the influence of technology on public policy
- Access to critical raw materials and defense of trading routes
- Threat analysis and net assessment
- Arms competition, nuclear proliferation and terrorism
- Systematic strategic resource analysis
- The political, military and economic issues in Europe since 1945
- Impact of oil revenues on Middle Eastern regional development and military balance
- Crisis management and trends in Soviet foreign policy
- Modeling Soviet and U.S. naval interaction
- Western and Soviety interests in the Mediterranean and the policies of surrounding states

# OPERATIONS RESEARCH / SYSTEMS ANALYSIS PROGRAM CURRICULUM NUMBER 360

**Joseph Henry Cyr**, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S. Purdue Univ., 1960; M.S., Naval Postgraduate School, 1969.

**Brian David Engler**, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., U.S. Naval Academy, 1969; Naval Postgraduate School, 1970.

**James Kern Hartman**, Academic Associate; B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970

## OPERATIONS RESEARCH/SYSTEMS ANALYSIS CURRICULUM CURRICULUM NUMBER 360 (GROUP RO)

OBJECTIVE — To supply the Services' needs for a cadre of military operations analysts for assignment to Department of Defense headquarters staffs, other major staffs, development groups, operational staffs and various Defense Department agencies.

This program provides education in the application of quantitative analyses to operational, tactical, and managerial problems. The disciplines of mathematics, probability, statistics, economics, human factors, physical science, and optimization which the officer student learns here or brings with him, supply the theoretical background for analyzing alternative choices in tactical and strategic warfare and in planning, budgeting and procurement of systems and forces. The course of study generates computational capability and develops skills in identifying relevant information, generating decision criteria, and selecting alternatives. This education enhances performance in all duties throughout a military career, including operational billets, technical management assignments and policy making positions.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above average grades in mathematics is required. Completion of mathematics through calculus is considered minimal preparation. A one year course in college physics is highly desired (Supply Officers excluded). Students lacking these quantitative prerequisites will be accepted, in certain cases, where their under-graduate records indicate that they are exceptional students and there are other possible indicators of success such as Graduate Record Examination scores, correspondence or extension courses in quantitative subjects, and outstanding motivation for the program.

ENTRANCE DATES:

March and September

DURATION:

Tailored to the student's qualifications; generally 1½ to 2 years.

DEGREE:

Requirements for the degree Master of Science in Operations Research are met as an included part of the curricular program.

DESCRIPTION — The Operations Research/Systems Analysis programs is interdisciplinary in nature, consisting of two phases: an introductory phase of basic courses which are required as prerequisites

for graduate level studies, and an advanced phase which permits the student to examine a selected area of analysis to some depth. The introductory phase is tailored to the individual's background and qualifications. This portion of the program is of variable length depending on the amount of course work listed below which can be validated by examination or credited from prior academic work. The length of the advanced phase is tailored to the curricular objectives and the requirements of the parent service or organization. A thesis is required in addition to the course work.

### Introductory Study

The introductory phase prepares students in the following disciplines:

- calculus
- linear algebra
- computer programming in FORTRAN
- applied physics (underwater acoustics, lasers, infra-red, radar, and defense communication systems)
- probability and statistics
- mathematical economics and resource allocation
- linear programming
- system simulation
- human factors in military system design

### Graduate Study

#### Core Courses

The advanced phase commences with required courses in the following disciplines:

- systems analysis
- war gaming
- stochastic models
- interactive computer techniques
- data analysis
- nonlinear and dynamic programming
- search theory and detection (USN Line)

EXPERIENCE TOUR — During the early part of the advanced phase the U.S. student is assigned a six-week experience tour with Department of Defense analysts and other groups engaged in analyses of military problems. International students are assigned experience tours consistent with classification considerations and their country's desires and at no cost to the U.S. government. Some agencies which have participated in the experience tour program in the past include:

- Office of the Chief of Naval Operations
- Office of the Secretary of Defense
- Joint Chiefs of Staff
- Naval Safety Center
- U.S. Army Concepts Analysis Agency
- Marine Corps Tactical Systems Support Activity
- Naval Systems Commands
- Supreme Allied Commander, Atlantic (SACLANT)
- Operational Test and Evaluation Force
- Naval Electronics Laboratories
- Bureau of Naval Personnel
- U.S. Army Combined Arms Development Activity
- Institute for Defense Analysis
- U.S. Arms Control and Disarmament Agency
- Navy Recruiting Command
- U.S. Army Operational Test and Evaluation Agency
- Experimental Squadron FIVE
- State Department
- Destroyer Development Group
- Submarine Development Group
- Project Managers under the Chief of Naval Material

THESIS RESEARCH — A thesis is required in addition to the course work. A total of 12 quarter hours are allocated for thesis research during the last half of the student's program.

OPTION COURSES — At the completion of the experience tour the student enters one of six "option" areas which offer specialization in a particular area in recognition of requirements of the officer's military service or corps, as well as his background and interests:

**Operations Evaluation (Navy) Option** — Preparation for dealing with the analysis of tactics and hardware in Naval warfare. Courses include:

- Search theory and detection
- Operations research problems in naval warfare
- Tactical design and analysis
- Skilled operator performance
- Operational test and evaluation

- Sound in the ocean
- Reliability and weapon system effectiveness
- Campaign analysis
- Application of search detection and localization models to ASW

**Operations Evaluation (Marine Corps, Army) Option** — Preparation for dealing with the analysis of land combat operations. Courses include:

- Combat models
- Quantitative analysis of tactics
- Operational test and evaluation
- Games of strategy
- Campaign analysis
- Design of experiments
- Reliability and weapons system effectiveness
- Operations research of Army weapons systems

**Systems Analysis Option** — Preparation for dealing with defense department resource allocation, planning programming. Courses include:

- Theory of systems analysis
- Econometrics
- Defense expenditure and policy analysis
- Cost estimation
- Campaign analysis
- Defense systems acquisition

**Human Factors Option** — Preparation for dealing with human performance evaluation and the design of man/machine systems. Courses include:

- Skilled operator performance
- Operations research in military man/machine systems
- Evaluation of human factors data
- Human performance evaluation
- Human factors in system design
- Design of experiments

**Logistics Option** — Preparation for dealing with supply systems for Navy Supply Corps and Quartermaster or Maintenance officers. Courses include:

- Inventory theory
- Military supply systems
- Financial and managerial accounting
- Time series analysis
- Military procurement and contract administration
- Military application of management information systems
- Physical distribution in supply systems
- Logistics engineering

**Advanced Modelling Option** — Preparation for dealing with the theory and techniques of operations research. Courses include:

- Design of experiments
- Network flows and graphs
- Stochastic models
- Reliability
- Inventory theory
- Games of strategy
- Mathematical programming

# WEAPONS ENGINEERING PROGRAMS CURRICULA NUMBERS 530, 531 AND 535

**Edward Joseph Mahon,** Commander, U.S. Navy, Curricular Officer, Weapons Engineering Programs; B.S., U.S. Naval Academy, 1957; B.S., Naval Postgraduate School, 1967.

**Chris Harold Cohlmeyer,** Lieutenant, U.S. Navy; Assistant Curricular Officer, Weapons Engineering Programs; B.S., U.S. Naval Academy, 1968; B.S., Naval Postgraduate School, 1975.

**John Norvell Dyer,** Academic Associate; B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

Several curricular programs are administered by the Weapons Engineering Curricular Office as follows:

530 Weapons Systems Technology
531 Weapons Systems Science
535 Underwater Acoustics

OBJECTIVE — The fundamental task of the Weapons Engineering subspecialty community is the design, development, test and evaluation, acquisition, operation and support of naval weapon systems. The weapons subspecialist's career pattern must be both technically and operationally sound in order to provide that happy combination of operational and engineering expertise. In support of this career pattern, the objective of these curricula at the Naval Postgraduate School is to provide that advanced technical education on a broad foundation encompassing the basic scientific, analytic and engineering principles underlying the field of naval weaponry. The specific areas of study and the levels of expertise to be attained are formulated for each curriculum to insure a sound basis for technical competence and for subsequent growth as may be required to support the fundamental task of the community.

This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments, and policy making positions, thereby preparing the officer for increased responsibility including command, both ashore and afloat.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with mathematics through differential and integral calculus is required for direct input. Courses in the physical sciences and engineering are desirable. Officers not having the required qualifications for direct input enter the program indirectly through the Engineering Science Curriculum discussed elsewhere in this catalog.

Officers may enhance their selectability by taking off-campus courses, including participation in the Postgraduate School Continuing Education program which has been outlined earlier in the catalog.

Allied officers may enroll in the above curricula subject to the exclusion of classified courses as determined by the Chief of Naval Operations.

DESCRIPTION — The structure of each curriculum takes into account the fact that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without

some preparation. The extent of the preparation will depend upon the academic background of the individual officer and will be decided upon by the officer student in consultation with his Curricular Officer and Academic Associate.

The curricula described below are interdisciplinary in nature because of the broad knowledge required of the graduate. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. In a typical program the first five quarters are devoted to the basic "core" material. Certain undergraduate portions of this core may be validated by an academically prepared officer to permit study to greater depth or breadth at the graduate level, or, subject to course scheduling limitations, to shorten his time on broad. The remainder of the program is dedicated to advanced graduate specialization in a specific technical field. Upon successful completion of an approved curriculum, officers will be assigned the appropriate Weapons Engineering subspecialty billet code and will be awarded the degree Master of Science in the appropriate discipline dependent upon academic achievement and successful completion of required courses. On-going counseling is provided by the Curricular Officer/Academic Associate team for all officer students and a close professional relationship between officer student and faculty enables each officer to make his time at the School a valuable asset to his professional development and career.

Descriptions of each curriculum and typical programs follow. Specific degree requirements may be found under the appropriate departmental section of the catalog.

## WEAPONS SYSTEMS ENGINEERING

Graduate education in weaponry and ordnance systems has long been one of the primary functions of the Naval Postgraduate School. As weapons systems have become increasingly complex, the need to keep pace with the rapidly emerging technology which governs the development and operations of these systems has never been greater. In order to optimally operate, manage and command these complex combat systems, it is essential that officers possess a wide range and depth of basic scientific knowledge in areas such as electronics, controls, lasers, electro-optics, computer systems, communications, radars, signal processing, materials science, explosives and propellants, plasmas, and nuclear science. The Weapons Systems Engineering programs provide graduate-level education in these and other areas of required expertise.

In addition to the formal course work and laboratories, officer students participate in and report on projects designed to investigate components of major weapons systems in order to exercise their experience and their education in considering the "real-life" aspects of weapons systems engineering.

A guest lecture and seminar program, plus visits a weapon-related field activities, serve to keep students informed of current developments and stress the present day utilization of theory and technology.

## INTRODUCTORY AND CORE COURSES

The Weapons Systems Technology and the Weapons Systems Science curricula are identical for the first five quarters. Additionally, four courses are common to both in the sixth through eighth quarters. The variation between these two curricula is achieved by means of different and varied specialization areas during the last four quarters.

The core portion of the program provides basic mathematical, scientific and engineering courses, along with an introduction to systems engineering, required for successful pursuit of the graduate electives, as well as those graduate studies required of all officers students. Each student's transcript will be evaluated for validation of as many of the introductory

courses as possible. The remaining courses will be programmed with a normal load of four courses each quarter.

The core courses, including some undergraduate level studies, typically cover the following areas:

- Calculus, linear algebra, differential equations
- Partial differential equations
- Mathematical transforms
- Probability and statistics
- Mechanics and fluid dynamics
- Geometrical and physical optics
- Atomic and molecular physics
- Electromagnetic wave theory and propagation
- Electrical engineering, linear systems analysis, control systems
- Thermodynamics and physical chemistry
- Computer modeling and programming
- Real-time computer systems
- Systems engineering for weapon systems
- Military communications and radar systems
- Engineering materials and structural failures
- Weapons systems integration

## WEAPONS SYSTEMS TECHNOLOGY CURRICULUM 530

DESCRIPTION — This program is designed to meet the needs of the military services for an officer having a strong broad-based technical education with particular applications toward weapons systems.

In addition to the introductory and core material previously described, all students in this curriculum take graduate level courses covering blast and shock effects and explosive chemistry. An in-depth option sequence of normally four courses is offered wherein students specialize in particular technical subject areas. Students also engage in thesis research in an area related to these advanced studies.

Graduates are normally awarded the degree Master of Science in Engr. Science. On a case basis, some students, dependent on option courses and undergraduate background, may earn a Master of Science degree in Electrical Engineering, Physics or Mechanical Engineering.

In view of the breadth of the 530 curriculum that addresses all aspects of weaponry, successful graduates, regardless of option, will receive the Weapons Systems Technology subspecialty XX61P.

### GRADUATE SPECIALIZATION

For the officer pursuing the Weapons Systems Technology program, a number of graduate options are available. The availability of these graduate sequences is dependent upon the student's academic qualifications and course scheduling feasibility. Commonly pursued areas of advanced study are:

- Advanced control systems
- Military radar and electronic countermeasure systems
- Electro-optics and laser technology
- Materials science
- Advance engineering mechanics and analysis
- Advanced military communications theory
- Computer applications to military systems
- Physical chemistry

This curriculum commences each March and September.

## WEAPONS SYSTEMS SCIENCE CIRRICULUM 531

DESCRIPTION — This program is designed to meet the needs of the military services for officers who have a strong broad-based technical education with graduate emphasis in engineering physics and its applications.

In addition to the introductory and core courses previously described, all students in this curriculum take advanced courses in electromagnetic phenomena and solid state physics. An in-depth option sequence of normally four courses is offered wherein students specialize in a particular scientific area. Students also engage in thesis research in an area related to these advanced studies.

Graduates of this curriculum are awarded a degree of Master of Science in Physics. By successful completion of the curriculum the student also earns the XX63P (physics) subspecialty code.

#### GRADUATE SPECIALIZATION

For the officer pursuing the Weapons Systems Science program, several graduate options are available. The availability of these graduate sequences is dependent upon the student's academic qualifications and course scheduling feasibility. Commonly pursued areas of advanced study are:

Electro-optics and laser technology
Nuclear physics
Plasma physics
Physical chemistry

This curriculum commences each March and September.

## UNDERWATER ACOUSTICS CURRICULUM 535

DESCRIPTION — Underwater Acoustics is an interdisciplinary program. Specific coverage is provided in such areas as propagation of sound in the sea, transducer theory, signal processing electronics, oceanography, and noise and vibration control. Successful completion of the curriculum permits the graduate to address the current and future military problems associated with underwater acoustics systems and to expand his base of professional knowledge and technical competence.

Courses are drawn principally from the fields of physics, electrical engineering, oceanography and mathematics. Although broadly based, the emphasis is on underwater acoustics and its applications to Undersea Warfare. As can be seen in the following list, courses included relate to the generation and propagation of sound in the ocean, military applications of underwater sound and the electrical engineering of instruments for the detection of underwater sounds. Also included are topics concerning the effects of the noise environment on people.

As an integral part of his program, each officer prepares a thesis under the guidance of a faculty member. Graduates earn a degree Master of Science in Engineering Acoustics.

In addition, the program includes short field trips, visits to facilities working on current military acoustic problems, and participation in such meetings as the Navy Symposium on Underwater Acoustics.

Within the Navy, successful completion leads to an approved subspecialty code of XX56P and thus qualifies the graduate officer for assignments to challenging subspecialty billets throughout the military establishment.

#### INTRODUCTORY STUDY

This portion of the program provides the necessary mathematics, electrical engineering, and physics required for successful pursuit of the graduate curriculum. Each student's transcript will be evaluated for validation of as much material as possible. The remaining studies will be scheduled with a

normal load of four courses each quarter.

Calculus review
Linear algebra
Differential equations
Mathematical methods
Review of vector mechanics and fluids
Thermal and dynamic properties of gases and liquids
Basic circuit theory
Circuit analysis
Communications theory
Electronic engineering fundamentals
Digital machines
Oceanography

**GRADUATE STUDY**

The graduate portion of the program includes courses in the following areas:

Partial differential equations and integral transforms
Applied probability
Electromagnetic wave propagation
Physics of underwater vehicles
Fundamental acoustics
Underwater acoustics
Propagation of waves in fluids
Transducer theory and design
Advanced acoustics laboratory
Seminar in applications of underwater sound
Mechanical waves in solids
Shock, vibration and noise control in military systems
Shock waves and nonlinear acoustics
Sonar systems engineering
Acoustic signal processing
Oceanographic factors in underwater sound

This curriculum commences annually each September.

# CURRICULA CONDUCTED AT OTHER UNIVERSITIES

PETER KENNETH STEVENSON, Commander, U.S. Navy; Manager, Civilian Institution Programs; B.S. in Engineering Science, Naval Postgraduate School, 1970; M.S. in Management, 1971.

| Curriculum | Number | Length | Institution | Primary Consultant |
|---|---|---|---|---|
| Chemistry | 382 | 2 yrs | Various | NAVSEASYSCOM |
| Criminal Law | 884 | 1 yr. | Various | JAG |
| Facilities Engineering | 47X | 1-2 yrs. | Various | NAVFACENCOM |
| Forensic Science | 885 | 1 yr. | Armed Forces Inst. of Pathology* | JAG |
| International Law | 887 | 1 yr. | George Wash. Univ.* | JAG |
| Joint Intelligence | 990 | 9 mos. | Defense Intell. Sch.* | NAVINTCOM |
| Labor Law | 886 | 1 yr. | Various | JAG |
| Law (Army Judge Advocate Officers Adv. Course) | 881 | 9 mos. | U. of Virginia | JAG |
| Logistics Management | 700 | 1 yr. | Air Force Inst. of Technology* | CHNAVMAT |
| Naval Const. & Engrg. | 510 | 2-3 yrs. | M.I.T. | NAVSEASYSCOM |
| Nuclear Effects (Phys) | 521 | 18 mos. | Air Force Inst. of Technology* | DEFNUCAGCY |
| Nuclear Engineering (CEC) | 572 | 18 mos. | Penn State Univ. | NAVFACENGCOM |
| Nuclear Engineering (ED) | 520 | 18 mos. | Penn State Univ. | NAVSEASYSCOM |
| Ocean Engineering | 472 | 1-2 yrs. | Various | NAVFACENGCOM |
| Ocean Law | 883 | 1 yr. | Various | JAG |
| Petroleum Admin. & Mgmt. | 880 | 1 yr. | Various | JAG |
| Petroleum Engineering | 630 | 1-2 yrs. | U. of Texas | NAVFACENGCOM |
| Petroleum Management | 811 | 17 mos. | U. of Kansas | NAVSUPSYSCOM |
| Pol-Mil (Western Hemisphere) | 685 | 18 mos. | Various | CNO |
| Public Affairs | 920 | 1 yr. | Various | CHINFO |
| Religion | 970 | 9 mos. | Various | CHCHAP |
| Retailing | 830 | 1 yr. | Michigan St.* | NAVSUPSYSCOM |
| Subsistence Technology | 860 | 1 yr. | Michigan St.* | NAVSUPSYSCOM |
| Supply Aquis/Distrib Mgmt | 810 | 12-18 mos. | Various | NAVSUPSYSCOM |
| Taxation | 882 | 1 yr. | Various | JAG |

*No NROTC Unit at Institution

*Spanagel Hall*

# ACADEMIC DEPARTMENTS and COURSE DESCRIPTIONS

The faculty of the Naval Postgraduate School performs its graduate-education functions in an organizational arrangement that includes eleven academic departments and three interdisciplinary academic groups, each headed by a designated chairman. The departmental affiliations of the faculty members, the advanced degree offerings, and the courses of study are contained in the individual department descriptions which follow.

In support of the courses of study, an active research program is carried on by the faculty and students. The research projects are supported by the Office of Naval Research, the Director of Naval Laboratories, the various Naval Systems Commands, and the National Science Foundation, as well as by other agencies and organizations. The ongoing projects cover a broad spectrum of research problems and include both theoretical and experimental investigations.

The faculty maintains close liaison with programs at Department of Defense research laboratories and development centers, and the knowledge acquired and maintained through this association is incorporated throughout the instructional program. Faculty members are formally cleared for classified matter, and storage and control facilities are available for all levels of security classification. This allows both students and faculty full access to classified material as needed.

The undergraduate-level courses included in the departmental offerings are taken by students, as required, to prepare them for the graduate-level program. Much of this preparatory subject matter is available for off-campus self-study through the School's Continuing Education Program. Information concerning the availability of a course in this study mode is included in the course description.

# DEPARTMENT OF ADMINISTRATIVE SCIENCES

*Students participating in discussions, projects and seminars.*

**Carl Russell Jones**, Professor of Administrative Sciences; Chairman (1965)*, B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

**Edwin Vance Alden**, Adjunct Professor of Management (1977); B.S., California State Polytechnic Univ., (SLO), 1961; M.P.A., Univ. of Southern California, 1970; Ph.D., 1977.

**James Kenichi Arima**, Associate Professor Operations Research and Behavioral Science (1969); B.A., Univ. of California at Los Angeles, 1948; M.A., George Washington Univ., 1957; Ph.D., Northwestern Univ., 1962.

**David Norman Burt**, Adjunct Professor of Acquisition (1977); B.A., Univ. of Colorado, 1954; M.S., Univ. of Michigan, 1965; Ph., D., Stanford Univ., 1971.

**James David Buttinger**, Lieutenant Commander, U.S. Navy; Instructor in Economics/Systems Analysis (1975); B.S., U.S. Naval Academy. 1967; M.S. Naval Postgraduate School, 1971.

**Paul Marshall Carrick**, Associate Professor of Management (1969); B.A., Northwestern Univ., 1949; Ph.D., Univ. of California at Berkeley, 1956.

**William Howard Church**, Professor of Management (1956); B.A., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

**John Wallis Creighton**, Professor of

Management (1967); B.S., Univ of Michigan, 1938; B.A., Hastings College, 1939; Ph.D., Univ. of Michigan, 1954.

**Alexander Clayton Crosby**, Commander, U.S. Navy; Assistant Professor of Administrative Sciences (1975); B.S., Univ. of California at Berkeley, 1957; M.B.A., Harvard Univ., 1972.

**Leslie Darbyshire**, Professor of Management (1962); B.A., Univ. of Bristol, 1950; D.B.A., Univ. of Washington, 1957.

**Stanley Michael Dean**, Associate Professor of Management (1973); B.A., Brigham Young Univ., (1962) M.B.A., Harvard Univ., 1964; D.B.A., 1974.

**Clyde Brooklyn Derr**, Associate Professor of Management (1974); B.A., Univ. of California at Berkeley, 1967; Ed.D., Harvard Univ., 1971.

**Richard Sanford Elster**, Professor of Management and Psychology (1969); B.A., Univ. of Minnesota, 1963; M.A., 1965; Ph.D., 1967.

**Carson Kan Eoyang**, Associate Professor of Management 1974); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

**Kenneth J. Euske**, Assistant Professor of Accounting (1978); A.B., Gonzaga Univ., 1967; M.B.A., Dartmouth, 1969; D.B.A., Arizona Univ., 1978.

**Raymond Lloyd Forbes, Jr.**, Lieutenant Commander, U.S. Navy; Assistant Professor of Administrative Sciences (1976); B.S., U.S. Naval Academy, 1959; M.A., United States International Univ., 1971; Ph.D., 1973.

**James Morgan Fremgen**, Professor of Accounting (1965); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

**William Cannong Giauque**, Associate Professor of Administative Sciences (1973); B.S., California Institute of Technology, 1963; M.B.A., Harvard Univ., 1968; D.B.a., 1972.

**Charles Bengt Gustafson**, Commander, U.S. Navy; Instructor in Administrative Sciences (1977); B. Arch., Miami Univ., 1957; M.S. in Management, Naval Postgraduate School, 1971.

**Fenn Clark Horton**, Associate Professor of Economics (1964); B.A. State Univ. of Iowa, 1950; M.A., Claremont Graduate School, 1967; Ph.D., 1968.

**Jerry Douglas Horton**, Commander, U.S. Navy; Instructor in Management (1976); B.S., U.S. Merchant Marine Academy, 1957; M.S., Naval Postgraduate School, 1966.

**Robert Russell Judson**, Adjunct Professor of Management (1973); B.A., Univ. of Illinois, 1951; M.S., 1955.

**Melvin Bernard Kline**, Professor of Management (1970); B.S., College of the City of New York, 1941; M.S., Stevens Institute of Technology, 1952; M.E., Univ. of California at Los Angeles, 1959; Ph.D., 1966.

**Shu Sheng Liao**, Associate Professor of Accounting (1971); B.A., National Taiwan Univ., 1965; M.S., Utah State Univ., 1968; Ph.D., Univ. of Illinois, 1971.

**Richard Allin McGonigal**, Commander, U.S. Navy; Associate Professor of Management (1974); B.S., Cornell Univ., 1951; B.D., Union Theological Seminary, 1954; S.T.M., Columbia Univ., 1966; Ph.D., Michigan State Univ., 1971.

**Alan Wayne McMasters**, Associate Pro-

fessor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

**Neil Patrick Miller**, Lieutenant Colonel, U.S. Marine Corps; Instructor in Administrative Sciences and Computer Sciences (1976); B.A., Univ. of California at Berkeley, 1956; B.A., Southern Colorado State College, 1965; M.S. Management/Data Processing, Naval Postgraduate School, 1966.

**Robert Gordon Nickerson**, Lieutenant Commander, U.S. Navy, Assistant Professor of Administrative Sciences (1977); B.S., U.S. Naval Academy, 1963; M.S., Stanford University, 1967; Ph.D., 1975.

**Joseph Frederick Owens**, Commander, Supply Corps, U.S. Navy; Instructor in Management (1976); B.A., Grinnell College, 1961; M.B.A., Columbia Univ., 1962.

**Lynn Carol Paringer**, Assistant Professor of Economics (1977); B.A., Univ. of Wisconsin (1972); M.A., Univ. of Wisconsin, 1976; Ph.D., 1978.

**Kenneth Leon Patterson**, Lieutenant Commander, U.S. Navy; Instructor in Management (1976); B.A., San Francisco State College. 1963; M.B.A., George Washington Univ., 1971.

**Clair Alton Peterson**, Associate Professor of Operations Research and Economics (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

**James Clay Robertson**, Lieutenant Commander, U.S. Navy; Instructor in Management (1976); A.B., Colgate Univ., 1967; M.B.A., Univ. of Virginia, 1974.

**Robert William Sagehorn**, Lieutenant Commander, U.S. Navy; Assistant Professor of Administrative Sciences (1975); B.S., California Maritime Academy, 1959; B.A., Naval Postgraduate School, 1970; M.S., 1975.

**Norman Floyd Schneidewind**, Professor of Information Science and Computer Science (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966.

**John David Senger**, Professor of Management and Behavioral Sciences (1957); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

**Jonathan Cilley Tibbitts, Jr.**, Commander, U.S. Navy; Assistant Professor of Administrative Sciences (1975); B.A., Whitman College, 1958; BSCE, California Institute of Technology, 1958; MSCE, Stanford Univ., 1971.

**Ronald Alfred Weitzman**, Associate Professor of Psychology (1971); B.A., Stanford Univ., 1952; M.A., 1954; Ph.D., Princeton Univ., 1959.

**David Richard Whipple, Jr.**, Associate Professor of Economics and Systems Analysis (1971); B.A., Univ. of St. Thomas, 1964; M.A., St. Mary's Univ., 1966; Ph.D., Univ. of Kansas, 1971.

**Chester Arthur Wright.** Assistant Professor of Social Psychology (1973); B.A., San Francisco State Univ., 1965; M.S., Univ. of California at Los Angeles, 1968.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Administrative Sciences.

### MASTER OF SCIENCE IN APPLIED SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in administrative sciences at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Department of Administrative Sciences. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

### MASTER OF SCIENCE IN COMPUTER SYSTEMS MANAGEMENT

1. A candidate for the degree of Master of Science in Computer Systems Management must complete satisfactorily either (A) a minimum of 56 quarter hours of graduate level course work or (B) a minimum of 48 quarter hours of graduate level course work and an acceptable thesis.

2. Core course requirements at the graduate level must be successfully completed or validated by advanced credit in each of the following areas:

Computer Science
Data Processing
Economics
Financial Management and Accounting
Material Management
Operations Research
Statistics

### MASTER OF SCIENCE IN TELECOMMUNICATIONS SYSTEMS MANAGEMENT

The degree of Master of Science in Telecommunications Systems Management will be awarded at the completion of an interdisciplinary program that satisfies the following requirements:

1. A minimum of 56 quarter hours of graduate-level work of which at least 12 quarter hours must represent courses at the 4000 level.

2. The program must consist of a minimum of graduate-level credit as follows:

| | |
|---|---|
| Administrative Sciences and Quantitative Methods | 40 |
| Communications Systems and Computer Science | 16 |

3. In addition to the 56 quarter hours of graduate-level course credit, an acceptable thesis shall have an advisor and a second reader, at least one of whom must be from the Department of Administrative Sciences.

4. The program must be approved by the Chairperson of the Department of Administrative Sciences.

### MASTER OF SCIENCE IN MANAGEMENT

The award of the degree of Master of Science in Management requires:

1. Completion of the Management Fundamentals program plus a minimum of eight (8) quarter hours of upper division courses in subjects directly pertinent to the nature and objectives of the particular curriculum. The Management Fundamentals program consists of a total of 34 quarter hours of 2000 and 3000 level courses, including a minimum of the following hours by disciplines:

| | |
|---|---|
| Accounting and Financial Management | 6 |
| Behavioral Science | 3 |
| Economics | 6 |
| Management Theory | 3 |
| Quantitative Methods | 8 |

2. The completion of a minimum of forty (40) quarter hours of graduate level courses, at least twelve (12) quarter hours at the 4000 level.

3. The completion of an approved sequence of courses in the student's area of concentration.

Examples of concentration areas are accounting and financial management, communications management, economics, management science, material management, personnel management, and systems acquisition management.

4. In addition to the 40 quarter hours of course work, the submission of an acceptable thesis on a topic previously approved by the Department of Administrative Sciences.

5. Final approval of a program leading to the Master of Science in Management shall be obtained for each student from the Chairman, Department of Administrative Sciences.

## SERVICE COURSES

*Upper Division Course*

**AS 2701 Introduction to Systems Engineering (3-0 to 4-0)**
This course provides the student with an introduction to system design and development, the underlying philosophy concepts and methodology of systems engineering and its application in the Department of Defense and the Navy. It establishes the foundation for other courses in the Weapon Systems Technology (WST) option of curriculum 530. Topics covered include systems engineering overview, the systems approach, the system life cycle and system design process, systems engineering disciplines. Emphasis is placed on the planning and design phases of the system life cycle. PREREQUISITE: None.

*Upper Division or Graduate Course*

**AS 3204 Defense Resource Analysis (4-0).**
The aim of this course is to present the nature, the aims, and limitations of analysis as it exists today and contributes to military problems. The common principles of cost/effectiveness analysis, design and formulation of the study, methods of solution, sensitivity analysis, pitfalls and limitations. Case studies from the field of interest of the class will be discussed. PREREQUISITE: None.

**AS 3340 The Defense Decision Process and ASW** (4-0). Study of the defense decision process as it related to the choice of ASW forces. Includes consideration of the systems acquisition system, the planning, programming and budgeting system, and their interrelationahip in setting the ASW force level and mix. The effect of the office of Management and Budget, and the Congressional budget process on ASW forces is also considered. Current status of Soviet submarine employment, hardware and doctrine. PREREQUISITE: Last quarter standing in the ASW curriculum.

**AS 3501 Project Management (4-0).**
Study of practical application of management processes in the project and systems acquisition environment. Planning, organization, staffing, directing and controlling functions are discussed. Behavioral aspects of motivation, leadership and interpersonal processes are included. Enrollment restricted to non-systems acquisition management students. PREREQUISITE: None.

**AS 3510 Organizational Behavior and Naval Intelligence** (4-0).
An examination of the different approaches to the study of public management and their relevance to the administration of naval intelligence. After a brief introduction to the organization theory, measures of organizational effectiveness and group decision making, a number of American intelligence organizations are analyzed. PREREQUISITE GV 3061.

**AS 3609 Introduction to Mathematical Economics** (4-0).
A presentation of the basic economic concepts involved in the decision process of individuals and other entities faced with scarcity of resources. The goal is to provide sufficient background to allow accurate incorporation of economic incentives in descriptive and optimization models constructed in the process of doing systems analyses. Topics covered include opportunity cost, incremental analysis and its relation to decision rules, linear and nonlinear production processes, partial equilibrium analysis, ordinal and cardinal utility and welfare criteria. PREREQUISITES: MA 2110, MA 2042.

**AS 3610 Utility Theory and Resource**

**Allocation (4-0).**
Extension of the concepts discussed in AS 3609 to the analysis of decisions involving welfare of groups of individuals. Covered are externalities, public goods, joint production, nonmarket decision making through shadow pricing. Also covered is an introduction to the macroeconomic structure within which the micro decisions previously covered are made. Included is income determination and sector analysis with policy discussions and evaluation. PREREQUISITE: AS 3609.

**AS 3611 Systems Analysis I (4-0).**
Principles of systems analysis and their relationship to the planning, programming, and budgeting system (PPBS), and the traditional OR models. Analysis of effectiveness measures and models. Cost estimating and analysis. Overall structure of cost-effectiveness and decision criteria. Risk and uncertainty problems. PREREQUISITES: OA 3604, AS 3910, PS 3303.

**AS 3703 Maintainability Engineering (4-0).**
Maintainability as a system design discipline. The system life cycle/decision process and maintainability. The maintainability program plan (MIL-STD-470). Maintenance engineering analysis. Developing the maintenance concept. Concepts of system effectiveness — reliability, maintainability, availability, dependability, and capability. Maintainability statistics, prediction, demonstration, and evaluation. (MIL-STD-471). Maintainability design requirements and trade-off analysis. Maintainability program management, design reviews, data collection. Case studies and examples. PREREQUISITE: OS 3202.

**AS 3704 Logistics Engineering (4-0)**
Integrated logistics support as a systems engineering discipline. Logistic support planning and the system life cycle. Logistics elements. Logistic support analysis (MIL-STD 1338). Level-of-repair analysis (MIL-STD-1390). Statistical techniques for logistics, resource analysis, provisioning and inventory control. Logistics interfaces with reliability and maintainability. Data requirements. Logistics management. PREREQUISITES: An introductory course in probability and statistics and a survey course in operation research.

*Graduate Courses*

**AS 4613 Theory of Systems Analysis (4-0).**
Systems analysis (cost-effectiveness analysis) formulated as commensurable and incommensurable physical capital investment choice models. Imphasis on decision rules and the nature of opportunity costs with respect to scale and timing of investment. Interpretation of methods of risk, modeling and solution computation. Theory of the second best; theory of the social discount rate. Introduction to models of planning and control emphasizing decentralization of the decision-making problem. PREREQUISITES: AS 3611. OA 4631 (concurrently).

## TELECOMMUNICATIONS SYSTEMS MANAGEMENT

**CM 0001 Seminar for Telecommunications Management Students (0-2).**
Guest lecturers. Theses and research presentations. PREREQUISITE: None.

**CM 0810 Thesis Research for Telecommunications Management Students (0-0).**
Every student conducting thesis research will enroll in this course.

*Upper Division or Graduate Course*

**CM 3184 Real-Time Information Systems (4-0).**
The study of real-time and on-line information systems from a functional and management standpoint. Topics covered are: the characteristics, effectiveness and system economics of selected DOD and civilian computer-communication networks and services; management of real-time system development and operations and analytical tools for evaluation of real-time systems. PREREQUISITES: CS 2303, MN 3105, OS 3211.

*Graduate Courses*

**CM 4184 Real-Time Information System Management (4-0).**
This course, given in the final quarter of the Communicaions Management curriculum, integrates material presented in previous courses. Cases and examples are considered

which are illustrative of the management problems confronting a communications manager in naval communication station or headquarters communications development activities. PREREQUISITES: CM 3184, EE 3425.

**CM 4925 Economics of Telecommunications (4-0).**
Study of the telecommunications industry and its regulations. Considerations of special issues: allocation of the spectrum, telecommunication service pricing, DOD lease decisions, and DOD supply of services. PREREQUISITES: MN 3170, OS 3211, MN 3101.

## COMPUTER SYSTEMS MANAGEMENT

**CT 0001 Seminar for Computer Systems Management Students (0-2).**
Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

**CT 0810 Thesis Research for Computer Systems Management Students (0-0).**
Every student conducting thesis research will enroll in this course.

### *Upper Division Course*

**CT 2000 Introduction to Computer Management (3-2).**
This course will provide an introduction to the field of automatic data processing and the functions and responsibilities of the computer manager. Specific topics are: survey of contemporary computer applications, hardware and software; functions and responsibilities of the computer manager; introduction to the role of personnel management, financial management, quantitative methods and computer science in computer management: NPS Computer Center operations, including management functions, computer room operators, hardware, operating system and programming. PREREQUISITE: None.

### *Upper Division or Graduate Course*

**CT 3220 Computer Center Operations (3-2).**
Theory and practice of the management of computer center operations. Specific topics include: facilities planning, production scheduling and control, operational procedures, computer performance evaluation, analysis of operating systems and hardware for installation and security of computer installations. A feature of the course is experience obtained in operating the NPS Computer Center installation. PREREQUISITES: CT 2000, CS 3010, CS 3020, CS 3030 concurrently, or equivalent.

### *Graduate Courses*

**CT 4182 Data Processing Management (4-0).**
Study of computer systems analysis and design. Management of ADP in the Federal Government, especially in the Department of Defense. Specific topics covered include: feasibility studies, selection, and acquisition of equipment; evaluation of computer hardware and software; installation and effective utilization of ADP equipment; and various types of computer applications. PREREQUISITE: a background of advanced work in information systems or computer science and Departmental approval.

**CT 4185 Computer-Based Management Information Systems (4-0).**
The application and design of computer-based information systems for management planning, control and operations. This is a required course in the Computer Systems Management Curriculum and also is offered as an elective for other students who have taken the prerequisites. PREREQUISITES: CT 2000, MN 3155 or equivalent, and OS 3210 or equivalent.

## MANAGEMENT

**MN 0001 Seminar for Management Students (0-2).**
Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

**MN 0810 Thesis Research for Management Students. (0-0).**
Every student conducting thesis research will enroll in this course.

### *Upper Division Courses*

**MN 2031 Economic Decision Making (4-0).**
The macroeconomic section includes a

presentation of methods of national income determination, the consumption function and multiplier concepts and the impact of fiscal and monetary policies. The microeconomic section covers an introduction to individual economic decision processes and their relation to attainment of market equilibria. PREREQUISITE: MA 2300 concurrently.

**MN 2106 Individual and Group Behavior (4-0).**
A survey of individual and group behavior with emphasis on those aspects which affect performance and satisfaction within an organization. Topics include motivation, learning, personality, leadership, group effectiveness and role behavior. PREREQUISITE: None. (*May be taken through Continuating Education as the minicourse sequence MN 2107-09*)*

*The minicourses are described in the Continuing Education catalog.

**MN 2150 Financial Accounting (4-0).**
Study of the basic postulates and principles of accounting. Specific topics include the accounting cycle, asset valuation, equities and capital structure and financial statement analysis. PREREQUISITE: None. (*May be taken through Continuing Education*)

**MN 2812 Communication in Organization (2-0).**
A survey of current practices, strategies, and problems in the field of Human Resources Management. This course is intended for Management students. *Graded on Pass/Fail basis only.*

*Upper Division or Graduate Courses*

**MN 3001 Behavioral Research Methodology (4-0).**
Introduction to epistemology and the philosophy of science. Hypothetical construct, intervening variables and operational definations will be discussed. An introduction to measurement and scaling will be given. Uses of inferential statistics and experimental method, both in the laboratory and in the field, will be examined. PREREQUISITES: MN 3105, PS 3211, and OS 3212 (concurrently).

**MN 3002 HRM Data Assessment (0-2).**
A laboratory course designed to apply quantitive methods to Human Resource Management data (e.g., Navy Survey data), including the processing and the display of such data and the demonstration of practical HRM evaluation and data-based problems. PREREQUISITE: MH 3001 (concurrently).

**MN 3101 Personnel Management and Labor Relations (4-0).**
Study of the principles and practices of personnel administration in business and government organizations. A survey of the history, development and current status of labor-management relations in industry and government. Analysis of the labor market and the implications of government regulations for wages and labor-management bargaining. PREREQUISITES: MN 3105, MN 3140, and MN 3161.

**MN 3105 Organization and Management (4-0).**
The study of the management of organizations emphasizing human and organizational variables and their implications for managerial action. Topics include the theories of management, organizational behavior, planning and control, and organizational development. PREREQUISITE: MN 2106. (*May be taken through Continuing Education*)

**MN 3110 Individual Behavior (4-0).**
Study of the basic characteristics and determinants of individual behavior. Specific topics include personality, motivation, learning, behavior conditioning, and introduction to tests and measurement. Implications for effective administrative practice. PREREQUISITE: MN 2106.

**MN 3111 Personnel Management Processes I (4-0).**
A broad coverage of human behavior in the work situation with special emphasis on the problem of work in the Naval environment. Topical areas covered include selection, placement, training, and evaluation of personnel; motivation, remuneration, morale, supervision, and working conditions in organizations; equipment design and man-machine relationships; and consumer (user) behavior and the impact of technological

programs. PREREQUISITES: MN 3105, PS 3211 (concurrently).

**MN 3112 Selected Topics in Human Resources (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 3114 Organization Development I (3-0).**
The course will cover basic principles of intervention theory and method. What constitutes a "healthy" organization, how to diagnose it and how to involve its participants to improve it from the actual to the desired state are critical study problems. Cases, experimental teaching methods and interactive discussions will be employed. PREREQUISITE: MN 3105.

**MN 3115 Human Resource Development (0-4).**
A laboratory course designed to complement Organization Development I (MN 3114), it will focus on a special assessment of individual student competencies needed to become effective interventionists. An action plan for developing and improving these competencies will be required. PREREQUISITE: MN 3114 (concurrently).

**MN 3116 HRM Field Work (0-4).**
A laboratory course to accompany Organization Development II (MN 4123), it emphasizes general OD field trips, visits to ongoing military HRM interventions and a project designed to apply theory to practice.PREREQUISITE: MN 4123 (concurrently).

**MN 3117 Workshop Design (0-4).**
A practicum designed as a companion course to Education and Training (MN 4116), to give students experience in designing, developing, implementing and assessing HRM workshops. PREREQUISITE: MN 4116 (concurrently).

**MN 3120 Planning and Control (4-0).**
Theory and techniques of the management functions of planning and control. Topics will include policy and strategy formulation, long- and short-range planning, goal-setting and management by objectives, budgeting and forecasting, performance evaluation and the use of rewards. PREREQUISITE: MN 3105 and MN 3161.

**MN 3121 Leadership and Group Behavior (4-0).**
The study of groups in different settings and factors affecting both individual and group behavior. Attention will be given to such concepts as authority, conformity, cohesiveness, effectiveness, and leadership. Emphasis will be placed on methods of observing group action. PREREQUISITE: MN 2106.

**MN 3123 Military Sociology (4-0).**
An exploration of classical theories of sociology pertaining to civil-military relations with modern applications to command and control problems. Sexism, racism, family dissolution, unionization, bureaucratic inertia, career patterns and professionalism are considered from the perspective of sociology. PREREQUISITES: MN 2106, MN 3105.

**MN 3124 Analysis of Bureaucracy (4-0).**
An analysis of the forms and processes of complex organizations in evolution from charisma to bureaucracy. Topics include formal dimensions of structure, informal structure, professionalism, basic growth and elaboration processes, and applications of general systems theory to organizational phenomena. PREREQUISITE: MN 3105.

**MN 3125 Organizational Behavior and Administration (4-0).**
Analysis of human situations and their administrative implications. The course focuses on the responses made by individuals and groups to the influences bearing upon their behavior in organizational settings. PREREQUISITE: MN 3105.

**MN 3126 Selected Topics in the Behavioral Sciences (2-0 to 5-0).** Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 3127 Selected topics in Organization and Management (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. May be repeated for

credit if the content changes. PREREQUISITE: Departmental approval.

**MN 3130 Macroeconomic Theory (4-0).**
Development of models to analyze the relationships between aggregate consumption, investment and output. Consideration of debt and financial assets, technical progress, growth, and monetary and fiscal control systems. PREREQUISITE: A course in Principles of Economics.

**MN 3135 Selected Topics in Economics (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in economics and Departmental approval.

**MN 3140 Microeconomic Theory (4-0).**
Determination of the allocation of resources and the composition of output. Consumer and Producer Choice Theory. Partial and general equilibrium analysis. Welfare economics. Applications to defense problems are emphasized. PREREQUISITES: MN 2031, MA 2300 or their equivalents.

**MN 3142 International Trade and Development (4-0)**
Study of the nature of trade between nations and the various approaches to economic development. Topics include trade and resource allocation, international finance, growth and development theory, and the market-public planning for development debate. Policy issues are considered with emphasis on the implications for national action. PREREQUISITE: A course in Principles of Economics.

**MN 3143 Managerial Economics (4-0).**
Microeconomic theory and its applications and capital budgeting; significance of market structure upon performance, investment decisions and capital budgeting. Case and Industry studies. PREREQUISITE: A course in Principles of Economics.

**MN 3146 Comparative Economic Systems (4-0).**
The characteristics and functions of economic systems. Criteria for evaluating performance. The analysis of alternative patterns of control, planning and market structures under capitalism, socialism, and mixed economics. PREREQUISITE: A course in Principles of Economics.

**MN 3155 Financial and Managerial Accounting (4-0).**
Study of both financial and managerial accounting. Introduces the accounting principles, practices and procedures associated with modern integrated systems. Specific topics include the accounting cycle, asset valuation, equities, capital, financial statement analysis, flexible budgets, cost volume profit analysis, and capital budgeting. *Closed to all students who must take MN 2150 and/or MN 3161.* PREREQUISITE: None.

**MN 3161 Managerial Accounting (4-0).**
Survey of cost accounting systems, including overhead costing, job order and process cost systems, variable and absorption costing, and standard costs. Emphasis is on application of accounting data to planning, control and decision making. Topics covered include flexible budgets, variance analysis, cost-volume-profit analysis, and incremental profit analysis. Capital budgeting is examined extensively. PREREQUISITE: MN 2150.

**MN 3165 Selected Topics in Accounting and Financial Mangement (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in accounting and financial management and Departmental approval.

**MN 3170 Defense Resource Allocation (4-0).**
The study of the process by which resources are allocated within the Department of Defense. Topics include an analysis of the planning, programming, and budgeting system and the systems acquisition process, cost-effectiveness analysis, and the economic, social and political environment of the military manager. PREREQUISITES: Financial and Managerial Accounting, Microeconomics or Managerial Economics, and a survey of operations research/system analysis.

**MN 3172 Public Policy Processes (4-0).**
A presentation of the processes by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3161, MN 3105. May also be offered as NS 3172.

**MN 3183 Management Information Systems (4-0).**
Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in computer-based and other information systems. Study of basic computer and MIS concepts as required, including computer and Data structure, input/output systems, file organization, programming and data-base management. PREREQUISITE: CS 2103 (concurrently).

**MN 3184 Management Information Systems and the Computer (4-0).**
Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in the Intelligence Data Handling System and other information systems. Study of basic computer and MIS concepts as required, including computer and data structures, input/output systems and file organization. Survey of COBOL programming and data-base management languages. This course is for 825 Naval Inteligence students only. PREREQUISITE: CS 0113 (concurrently).

**MN 3185 Information Systems for C3 (4-0).**
Study of what constitutes a Military information system relative to command, control and communications (C3). Includes concepts of systems theory, computer networks, value of information, distributed data processing and human behavior. Emphasis on the role of information processing in joint C3 applications. Oraganizational considerations which may enhance or impede use of a MIS are introduced. This course is designed for Command, Control and Communications students and will be taught in part at the SECRET level. PREREQUISITES: CS 2105, CO 3111.

**MN 3215 Selected Topics in Management Science (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 3251 Accounting Theory and Standards (4-0).**
Study of the basic concepts, standards, principles, and practices underlying published financial reports. Specific topics include approaches to the specification of accounting principles, bases of asset valuation, income measurement, and the measurement of corporate equities. Attention is devoted to current generally accepted accounting principles, to controversial reporting problems, and to prospective new developments. PREREQUISITES: MN 3161.

**MN 3371 Procurement and Contract Administration (4-0).**
Study of the elements of the procurement process. Coverage includes the determination of requirements, techniques used in purchasing, the military-industrial complex and its role in providing material and service, the management of on-going programs, and the environment in which the acquisition takes place. Military procurement regulations are analyzed to determine their impact on efficient military logistics systems. PREREQUISITES: MN 3140 or MN 3141.

**MN 3372 Material Logistics (4-0).**
The quantitative analysis of material logistics systems and supply management problems. Elements of study include inventory theory, data reporting, forecasting, order processing and system-wide design problems. PREREQUISITE: PS3211 (Concurrently).

**MN 3373 Transportation Management (4-0);**
Provides a knowledge of problems and practices encountered in the management of transportation systems. Areas covered include the study of present and future trends in military and commercial transportation systems. PREREQUISITES: MN 3140 or MN 3141.

**MN 3374 Production Management (4-0).**
This course examines the production process. Emphasis is distributed among the technical, managerial, and defense aspects of production. Topic coverage ranges from production planning through production control. PREREQUISITES: MN 3105 and PS 3211 and OS 3212.

**MN 3376 Selected Topics in Material Logistics (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 3645 Investigative Methods of Economics I (4-0).**
Development and applications of econometric models of particular interest to public sector managers. Topics include demand forecasting, production function estimates and cost estimating. PREREQUISITES: MN 3140 or MN 3141, and OS 3212 (concurrently).

**MN 3650 Health Economics (4-0).**
An overview and analysis of the underlying elements of the continuing problems in the military and civilian health care delivery sectors. Elements covered are: organizational structure and change in the mode of delivery of health care; Supply, Demand and Output and Quality Measurement of health services; the impact of health care legislation; the interrelations of the military and civilian sectors. PREREQUISITES: Microeconomics, e.g., MN 3140, AS 3610 or equivalent.

**MN 3760 Manpower Economics I (4-0).**
This course contains both theoretical and empirical issues in manpower economics. The theoretical development emphasizes individual employment, job searching, mobility and career decisions. Empirical work presented will include studies on the all-volunteer force, hazardous duty compensation and reenlistment bonuses. PREREQUISITES: MN 3140 or 3141, or AS 3609.

**MN 3801 Seminar in Technology Transfer (4-0).**
The study of dissemination and utilization of technology and associated problems with emphasis on communications, sociology, and organizational factors. PREREQUISITE: MN 3105 or graduate standing in a technical curriculum with consent of Instructor.

**MN 3811 Communication in Organizations (4-0).**
A survey of current management strategies to more effectively employ human resources in achieving mission accomplishment. The organizational development approach to communication will be used to help students expand their communication skill. *Graded on Pass/Fail basis only.*

**MN 3960 Readings in Management (2-0 to 5-0).**
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

**MN 3970 Seminar in Management (2-0 to 5-0).**
Content of course varies. Students will be allowed credit for taking this course more than one time. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

### Graduate Courses

**MN 4105 Management Policy (4-0).**
Study and appraisal of a variety of policies requiring the analysis of problems and the formulation of decision in both business and governmental enterprises. Use of case material, management games, and other devices as exercises in decision making and the executive action under conditions of uncertainty and change. PREREQUISITE: Open only to students in their final quarter of a Management Masters Program.

**MN 4106 Manpower Personnel Policy Analysis (4-0).**
Study and analysis of manpower/personnel policy alternatives with emphasis on identifying the trade-offs involved, the dynamic impact of major policy decisions, and the short-term and long-term consequences of decisions. Review, use and evaluation of tools to aid in selecting policy alternatives. Study of representative cases. PREREQUISITE: Open only to students in their final quarter of a

Management Masters program.

**MN 4110 Personnel Management Processes II (4-0).**
Emphasizes the integration of specific personnel management procedures and practices into programs with special emphasis on areas of current interest to military and civilian personnel administration. Programs will be examined with respect to their background and objectives, specific actions being taken and the rationale therefor, and factors impacting on their potential success and failure. The management of manpower-personnel research, development, and implementation will be revised. PREREQUISITE: MN 3111.

**MN 4111 Human Resources Seminar (4-0).**
A combination of readings and individual student research reports in the area of human resource goals. Emphasis on empirical analysis. PREREQUISITE: Departmental approval.

**MN 4112 Personnel Selection and Classification (4-0).**
Analysis of human performance within organizations. This course considers the methods available for measuring and predicting the performances of the members of organizations. Methods of measuring differences between people via employment interviewing, testing, and life-history data are discussed. Techniques for studying and recording job behavior are also considered. In addition, the various strategies for personnel decisions are discussed in terms of validation, and selection and placement models. PREREQUISITES: MN 3111 or Mn 3101.

**MN 4113 Personnel Training and Development (4-0).**
Determination of skills, knowledges and attitudes in which people should be trained. Analysis of who should be trained and the methods currently available for training are discussed. Techniques available for evaluating the efficiency of training are also considered. PREREQUISITES: MN 3111 or MN 3101.

**MN 4114 Personnel Performance Evaluation (4-0).**
Current methods of appraising the work performance of individuals in different types of work are reviewed. Problems associated with each method are analyzed. Performance evaluation is examined as a system interfacing with selection, classification, training, advancement, and retention. PREREQUISITES: MN 3111 or MN 3101.

**MN 4115 Personnel Motivation (4-0).**
A brief summary of the traditional theories of motivation is given. Several motivation to work theories are discussed along with the research concerning these theories. Current research on the roles of compensation in personnel motivation is considered. PREREQUISITE: MN 3110.

**MN 4116 Education and Training (4-0).**
This course concentrates on adult learning theory, curriculum design and instructional technology to help students teach, develop and supervise curriculum and instruction. The course is especially oriented to the needs of the Human Resource Management community. PREREQUISITE: MN 3105.

**MN 4121 Organizational Theory (4-0).**
This course provides an indepth theoretical perspective on complex organizations. It provides the student with conceptual tools for understanding the external environment, forms and structures, goals, systemic procedures and person-group-organizational interfaces. PREREQUISITE: MN 3105.

**MN 4123 Organization Development II (3-0).**
A study of the field of organization development. The course provides knowledge and skills of organization development and consultative skills to improve organizational effectiveness. The course covers major theories of organization growth and development and a variety of OD strategies designed to improve organizational functions. Students will have opportunities to demonstrate and refine their individual skills in small group settings. PREREQUISITE: MN 3114.

**MN 4126 Selected Topics in the Behavioral Sciences (2-0 to 5-0)**
Presentation of a wide selection of topics from the current literature. May be repeated for

credit if the content changes. PREREQUISITE: Departmental approval.

**MN 4127 Selected Topics in Organization and Management (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 4133 Economics of Computers (4-0).** Analytical tools of microeconomics and statistics applied to decision making in computer management. Economics issues and legal constraints related to computer hardware and software systems are discussed. PREREQUISITES: MN 3143, PS 3000 or PS 3011 and CS 2103 or CT 2000.

**MN 4142 International Trade and Development Policy (4-0).**
Leading issues in trade and development policy. Consideration of the implication of alternative economic systems on national policies. PREREQUISITE: MN 3142.

**MN 4145 Systems Analysis (4-0).**
This course will concentrate on the analysis of large scale defense resource allocation problems, using cost-effectiveness models. Topics include: discounting, constrained optimization, estimation problems, and efficiency over time. Systems analysis case studies will be emphasized. PREREQUISITES: MN 3172.

**MN 4147 Industrial Relations (4-0).**
Development of the institutions and techniques for resolving conflict over wages and conditions of work. Theories of bargaining and abritration. PREREQUISITE: MN 3101 or MN 3111.

**MN 4151 Internal Control and Auditing (4-0).**
Study of the objectives and procedures of internal control in government and industry. Examination of the independent audit function, including auditing standards and reports. Study of internal auditing, with emphasis on operational audits. Consideration of the principal Federal audit organizations. Specialized topics including sampling techniques for auditing, audits of computer-based systems, and audit problems associated with selected assets and operations. PREREQUISITES: MN 3161, MN 3183, and PS 3211, or their equivalents.

**MN 4152 Decision Making for Financial Management (4-0).**
The management of the finance function in industry, with particular attention to defense contractors. Specific topics include cash and working capital management, long-term financing, determination of optimal capital structure, and valuation of a going concern. PREREQUISITES: MN 3161 and MN 3140 or equivalent.

**MN 4153 Seminar in Accounting and Control (4-0).**
Research and discussion of current developments and controversies in accounting and financial controls for government and industry. Students will be expected to do individual or small-group studies and to make reports thereon. PREREQUISITES: MN 3161 and permission of Instructor.

**MN 4154 Financial Management in the Navy (4-0).**
Review of financial management and fund control procedures in DOD and the Navy. Includes study of PPBS, Comptrollership, Budget Formulation and Execution, Headquarters and Field Accounting Systems, and Types of Navy Funds. Students will be expected to do individual or small-group studies and to make reports thereon. PREREQUISITES: MN 3161 and MN 3172.

**MN 4161 Financial Control Systems (4-0).**
Study of the structure and process of financial control in governmental organizations in general and DOD in particuar. Specific topics include the basic concepts of management control, the measurement of inputs and outputs, pricing public services, programming, budgeting, accounting, and performance analysis. PREREQUISITES: MN 3105 and MN 3161.

**MN 4162 Cost Accounting (4-0).**
Review of various definitions of cost and alternative ways of measuring cost. Study of cost accounting systems, methods of allocating costs to cost objects, and the costing of activities, products, and projects. Consideration of the objectives and the substance of Cost Accounting Standards for negotiated

defense procurement contracts. PREREQUISITES: MN 3161, PS 3211.

**MN 4165 Selected Topics in Accounting and Financial Management (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in accounting and financial management and Departmental approval.

**MN 4181 Applications of Management Information Systems (4-0).**
Advanced study of management information as it relates to various organizational systems. Students will study actual industrial and/or military organizations in the context of management information systems. The issues of design, implementation, and operation of a management information system will be considered through the use of case studies of industrial and military organizations. This course is primarily for management students. PREREQUISITE: MN 3183.

**MN 4185 Selected Topics in Information Systems (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITES: A background of advanced work in information systems and Departmental approval.

**MN 4191 Decision Analysis (4-0).**
Discussion of the major topics of decision analysis, including decision theory, single- and multi-attribute utility theory, value of information, and modelling techniques. The course includes exposure to and use of computer models to structure and solve problems. PREREQUISITE: OS 3212.

**MN 4192 Workshop in Management Science (2-0 to 5-0).**
This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 4193 Selected Topics in Management Science (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 4225 Labor Law (4-0).**
Labor Law as it affects management, labor and the public with special emphasis on legal problems confronting military personnel in managerial situations. PREREQUISITE: MN 3101.

**MN 4371 Procurement Policy (4-0).**
Case study appraisals of business and government procurement policies. Emphasis is on procurement decision making and policy formulation through the case analysis method. PREREQUISITE: MN 3371.

**MN 4373 Transportation Policy (4-0).**
Advanced study in the management of transportation systems. Emphasis on coordinated transportation management in large-scale systems and its implication for DOD. PREREQUISITE: MN 3373.

**MN 4376 Seminar in Material Logistics (4-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

**MN 4650 The Military Health Care Delivery System (4-0).**
This course is designed to acquaint the student with the structure and operation of the Department of Defense's system for providing health care to those eligible under current regulations; to identify current problem areas, and through application of systems analysis and management techniques to address the possible solutions to these problems in a course project. PREREQUISITE: MN 3650.

**MN 4651 Hospital Economics and Systems Analysis (4-0).**
This course deals analytically and empirically with the major organizational and economic structures and problems associated with the operation of a health care delivery facility or group of facilities (e.g., hospitals or integrated groups of clinics). The roles of institutional incentives, methods of reimbursement, provider organization and payment, and exogenous factors such as general inflation and legislative parameters are discussed. The objective is a working background knowledge of these major elements in the health care production process and probable systemic

change. PREREQUISITES: MN 3140 and MN 3630.

**MN 4652 Micro Health Systems Analysis (4-0).**
The purpose of this course is to analyze in-depth, and using analyses of extant institutional constructs, the potential for deriving policy recommendations and designing research to motivate more efficient provision of health care by individual facilities. The emphasis will be on identifying gaps in incentives and organizational structures which lead to sub-optimal facility behavior in the cost containment and quality areas. PREREQUISITES: MN 3140, MN 3650, MN 4650 and MN 4651.

**MN 4761 Manpower Economics II (4-0).**
This course is designed to acquaint the student with human capital theory and to explore its relevance within the military. Included will be studies on the costs and benefits of investments in training both from the military's and the indivudual's point of view. The components of general and specific training will be reviewed and applied to the military. The institutional, social and economic considerations which affect human capital investments will be studied (including collective bargaining, discrimination, fringe benefits). PREREQUISITE: MN 3760.

**MN 4920 Public Expenditure Analysis (4-0).**
A presentation of basic concepts such as public goods, joint production and externalties which necessitate governmental market intervention. Techniques to analyze the effects and desirability of particular government expenditures are covered and include the theory of second best, cost-benefit analysis, consumer surplus, and social discounting. PREREQUISITES (MN 3140 and MN 3170 or 3172 or AS 3611.

**MN 4941 Microeconomic Theory and Policy (4-0).**
Advanced study of equilibrum and disequilibrium microeconomic systems. Topics include consumer choice, producer choice, market structure, risk, imperfect competition and regulation, and economic planning models. Policy issues and their implications for national action PREREQUISITES: MN 3140 or MN 3141 and Departmental approval.

**MN 4942 The Structure, Conduct and Performance of the Defense Industries (4-0).**
A study of selected defense industries structure (e.g., seller concentration, product differentiation, barriers to entry, demand for products, buyer concentration), conduct (e.g., pricing policy, product characteristics policy, policies toward rivals, policies toward customers), and performance (e.g., efficiency, progress, employment). The government as consumer and regulator. Typical industries covered are aerospace, computers, shipbuilding and telecommunications. PREREQUISITES: Microeconomics (MN 3140 or MN 3141 or MN 3143, or AS 3609).

**MN 4945 Selected Topics in Economics (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in economics and Departmental approval.

**MN 4950 Workshop in Management (2-0 to 5-0).** This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval *Graded on Pass/Fail basis only.*

**MN 4960 Readings in Management (2-0 to 5-0).**
This course may be repeated for credit if course content changes. PREREQUISITES: Departmental approval. *Graded on Pass/Fail basis only.*

**MN 4970 Seminar in Management (2-0 to 5-0).**
Content of course varies. Students will be allowed credit for taking this course more than one time. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

## SYSTEMS ACQUISITION MANAGEMENT

**SM 0001 Seminar For Systems Acquisition Management Students (0-2).**
Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

**SM 0810 Thesis Research for Systems**

**Acquisition Management Students. (0-0).** Every Student Conducting thesis research will enroll in this course.

*Upper Division Courses*

**SM 2308 Introductions to Systems Engineering (4-0).**
This course provides the student with an introduction to system design and development, the underlying philosophy, concepts and methodology of systems engineering, and its application in the Department of Defense and the Navy. It establishes the foundation for later courses in reliability, maintainability and logistics. Topics covered include systems engineering overview, the system life cycle and system design process, decision analysis, and the systems engineering disciplines. Emphasis is placed on the planning and design phases of the system life cycle. PREREQUISITE: PS 3201 or equivalent.

**SM 3301 Introduction to Systems Acquisition (4-0).**
This course provides students with an overview of the Systems Acquisition process, its underlying philosophies and concepts, its application in the Department of Defense and the Navy, and establishes the foundations for other courses in the curriculum. Topics covered include the evolution of systems acquisition management, the systems approach, the system life cycle and defense system acquisition cycle, user-producer acquisition management diciplines and activities. PREREQUISITE: Enrollment in the Systems Acquisition Management curriculum.

**SM 3302 Fundamentals of Project Management (4-0)**
Study of the principles of management as a body of knowledge related to practice. Discusses the functions of management planning, organizing, staffing, directing, and controlling — as they apply within industry and government. Specific application of these principles and functions to project management are investivated. PREREQUISITES: MN 2106 and SM 3301.

**SM 3303 Procurement Management (4-0).**
Study of procurement planning, negotiation, and contract administration, including the determination of need, basic contract law, methods of procurement, fundamentals of the Armed Services Procurement Regulations, and current procurement management techniques. Topics include procurement organizations, procurement by formal advertising and negotiation, source selection, pricing, types of contracts, structuring incentives and the terms and conditions of contracts, managing contract progress, change control, cost control, and contract termination. PREREQUISITE: SM 3301 or AS 3501.

**SM 3304 Procurement Planning and Contract Negotiation 4-0).**
Study of the procurement planning and negotiation phasis of the procurement cycle, including the determination of need, basic contract law, methods of procurement, fundamentals of the Armed Services Procurement regulations and current procurement management techniques. Topics include procurement organizations, procurement by formal advertising and negotiation, source selection, pricing, types of contracts, structuring incentives, and the terms and conditions of contracts. PREREQUISITE: SM 3301.

**SM 3305 Contract Administration (4-0).**
This course stresses the management skills and techniques necessary for the successful administration of Government prime contracts and subcontracts. Topics include defense procurement contract administation, managing contract progress, change control, cost control, and contract termination PREREQUISITE: SM 3304.

**SM 3307 Industrial Economics (4-0).**
This course provides the student with economic insights into the functioning of the industrial marketplace, including competitive and single customer market types. Basic economic concepts are introduced such as economic choice, production and cost functions, supply and demand equilibrium. Primary application of these concepts is to industry structures and cost-effectiveness studies. PREREQUISITE: None.

**SM 3308 Economic Analysis in Defence (4-0).**
This course is concerned with the analysis of defense resource allocations including methods used in estimating costs and military effectiveness for selecting among alternative

system concepts and for making performance, cost, and schedule trade-offs. Navy and other case studies are used to illustrate the concepts and methods. PREREQUISITES: SM 3307, PS 3202.

**SM 3309 Maintainability Engineering (3-0).**
The maintainability program plan (MIL-STD-470). Maintenance engineering analysis. Developing the maintenance concept. Concepts of system effectiveness — reliability, maintainability, availability, dependability, and capability. Maintainability statistics, prediction, demonstration, and evaluation (MIL-STD-471). Maintainability design requirements and trade-off analysis. Maintainability program management, design reviews, data collection. Case Studies and examples. PREREQUISITES: SM 2308, PS 3202.

**SM 3310 Manpower Personnel Planning and Analysis (4-0).**
Examines procedures and principles for establishing positions and acquiring and administering staff personnel, including pertinent aspects of industrial relations. Reviews principles, procedures, and practices for establishing qualitative and quantitative personnel and training requirements for new systems and major modifications. PREREQUISITES: MN 2106, SM 3302 (concurrent).

**SM 3311 Acquisition Management Simulation (0-4).**
This course is a system life cycle, computer-based simulation, interactive laboratory exercise in which the students, in teams, plan, organize and manage the development and production of a missle system. Trade-offs among performance, reliability, cost, and schedule, evaluation of technical proposals, contract and incentive negotiations, and DSARC reviews are included. PREREQUISITES: SM 3303, SM 2308, SM 3309, OS 3306.

*Graduate Courses*

**SM 4302 Public Expenditure, Policy and Analysis(4-0).**
The process of national decision-making particularly as reflected in the defense budgeting process. Models of budget decision making, including decentralization. Application of social choice concepts. Application from the defense budgeting process. PREREQUISITES: MN 3161, MN 4145.

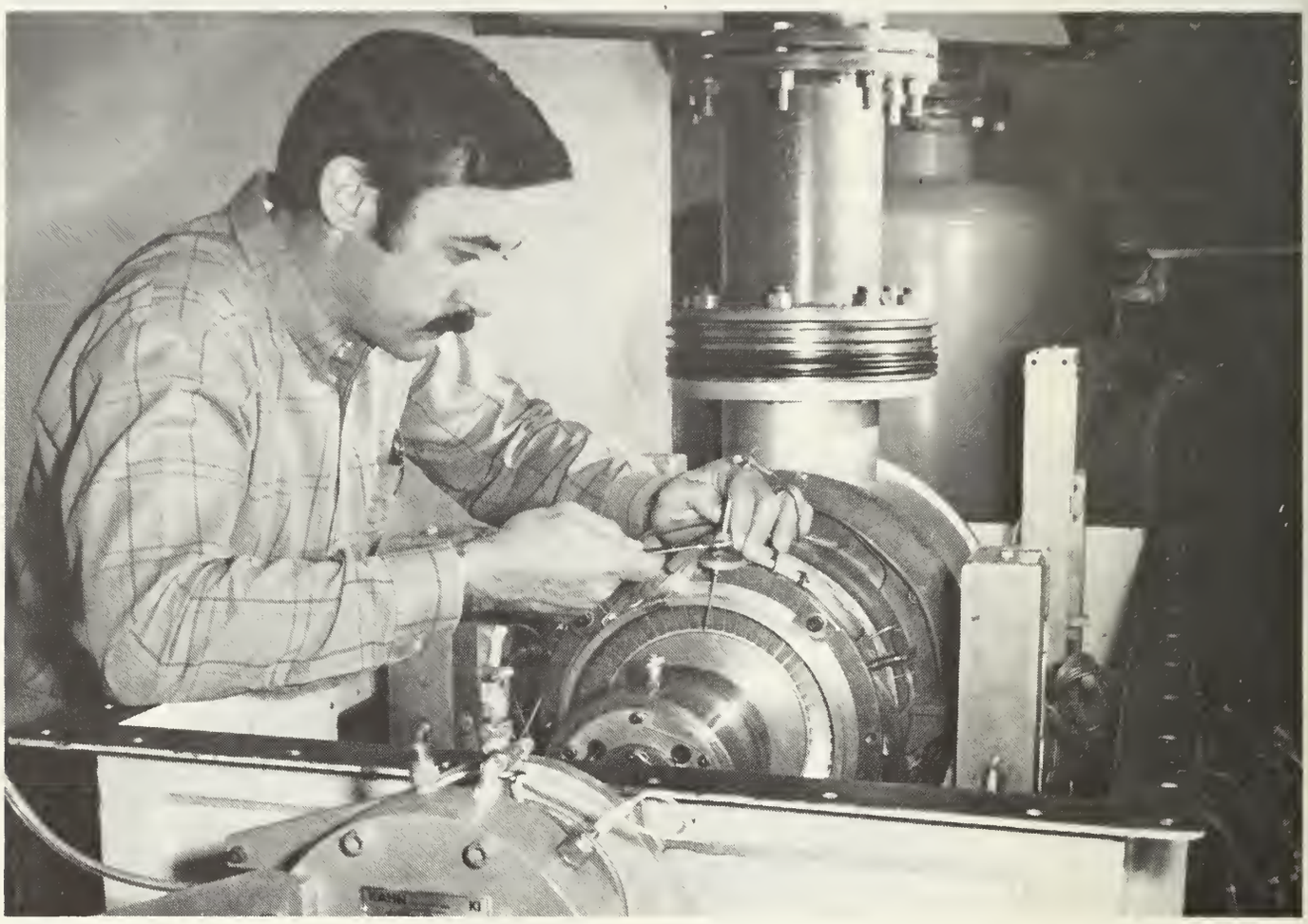
**SM 4304 Seminar in Systems Acquisition (4-0).**
Presentation of a wide selection of topics from current literature and research in systems acquisition. PREREQUISITES: SM 3305, SM 4305 or Department approval. Graded on Pass/Fail basis only.

**SM 4305-4306 Systems Engineering Management I-II (4-0).**
The objective of these courses is to provide the students with the opportunity to study real-world Navy project management decision-making. It covers technical management as applied to the systems acquisition process and stresses systems engineering disciplines and their life cycle integration with emphasis on preformance, cost and schedule trade-offs. The course is conducted by means of lectures and readings on systems engineering and the systems engineering disciplines, in-depth study of life-cycle management of selected Navy projects by teams of students and participation in the Defense Management. Simulations (DMS) exercise. PREREQUISITES: SM 3304, SM 3306.

**SM 4307 Acquisition Management Policy and Control Systems (4-0).**
This is a capstone course including discussion and examination of management control processes and tools, design and application of control systems, and design and use of management information systems, with emphasis on real-world practical systems. Application of computer-based systems is included. PREREQUISITES: SM 3302, SM 3308, CS 2010, CS 2104.

**SM 4310 Logistics Engineering (3-0).**
Logistics elements. Logistic support analysis (MIL-STD-1388). Level-of-repair analysis (MIL-STD-1390). Statistical techniques for logistics, resource analysis, provisioning and inventory control. Logistics interfaces with reliability and maintainability. Data requirements. Logistics management. PREREQUISITES: SM 2308, PS 3202, OS 3206.

# DEPARTMENT OF AERONAUTICS



*Student conducting research on Axial Turbine Test Rig.*

**Max Franz Platzer**, Professor of Aeronautics; Chairman (1970)*; Dipl Ing., Tech. Univ. of Vienna, Austria, 1957; Dr. Techn. Sci., 1964.

**Robert Edwin Ball**, Associate Professor of Aeronautics (1967); B.S. in C.E., Northwestern Univ., 1958; M.S., 1959; Ph.D., 1962.

**Richard William Bell**, Professor of Aeronautics; (1951); A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

**Oscar Biblarz**, Associate Professor of Aeronautics (1968); B.S., Univ. of California at Los Angeles, 1959; M.S. 1963; Ph.D., Stanford Univ., 1968.

**Daniel Joseph Collins**, Professor of Aeronautics (1967); B.A., Lehigh Univ., 1954; M.S. in M.E., California Institute of Technology, 1955; Ph.D., 1961.

**Theodore Henry Gawain**, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

**Charles Horace Kahr, Jr.**, Professor of Aeronautics (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

**Donald Merrill Layton**, Associate Professor of Aeronautics (1968); B.S., Naval Academy, 1945; B.S.A.E., Naval Postgraduate School, 1953; M.S. in A.E., Princeton Univ., 1954; M.S. in Management, Naval Postgraduate School, 1968.

**Gerald Herbert Lindsey**, Professor of Aeronautics (1965); B.E.S. in M.E., Brigham Young Univ., 1960; M.S. 1962; Ph.D., California Institute of Technology, 1966.

**James Avery Miller**, Associate Professor of Aeronautics (1963); B.S. in M.E., Stanford Univ., 1955; M.S. in M.E., 1957; Ph.D., Illinois Institute of Technology, 1963.

**David Willis Netzer,** Associate Professor of Aeronautics, (1968); B.S.M.E., Virginia Polytechnic Institute, 1960; M.S.M.E., Purdue Univ. 1962; Ph.D., 1968.

**Louis Vincent Schmidt,** Professor of Aeronautics, (1964); B.S., California Institute of Technology, 1946; M.S., 1948; Ae.E., 1950; Ph.D., 1963.

**Raymond Parmous Shreeve,** Associate Professor of Aeronautics (1971); B.Sc., Imperial College, London, 1958; M.S.E., Princeton Univ. 1961; Ph.D., Univ. of Washington, 1970.

**Robert Diefendorf Zucker,** Associate Professor of Aeronautics (1965); B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

### EMERITUS FACULTY

**Wendell Marois Coates,** Distinguished Professor Emeritus (1931); A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

**Ulrich Haupt,** Associate Professor Emeritus (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

**George Judson Higgins,** Professor Emeritus (1942); B.S., in Eng. (Ae.E.), Univ. of Michigan, 1923; Ae.E., 1934.

**Henry Lebrecht Kohler,** Professor Emeritus (1943); B.S., in M.E., Univ. of Illinois, 1929; M.S. in M.E., Yale Univ., 1930; M.E., 1931.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

### DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following are academic requirements for the award of degrees as determined by the Department of Aeronautics. In addition the general minimum requirements as determined by the Academic Council must also be satisfied.

The entrance requirement for study in the Department of Aeronautics generally is a baccalaureate in engineering earned with above average academic performance. This requirement can sometimes be waived for students who have shown distinctly superior ability in backgrounds other than engineering but who have had adequate coverage in the basic physical and mathematical sciences. All entrants must obtain the approval of the Chairman, Department of Aeronautics.

Students who have not majored in Aeronautics, or who have experienced a significant lapse in continuity with previous academic work, initially will take preparatory courses in aeronautical engineering and mathematics at the upper division level, extending through the first two to three academic quarters and constituting a portion of the coursework for degrees in Aeronautics. Final approval of programs leading to degrees in Aeronautical Engineering must be obtained from the Chairman, Department of Aeronautics.

### MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

Upon completing the preparatory courses, students may be selected on the basis of academic performance for the degree program leading to the Master of Science in Aeronautical Engineering. However, students who have recently earned a degree with major in Aeronautics may apply for admission directly to the graduate program.

The Master of Science degree requires a minimum of 36 credit hours of graduate courses, of which

at least 20 credit hours shall be at the 4000 level. It also requires that not less than 32 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 20 hours of courses in the Department of Aeronautics and a minimum of 8 hours in other departments.

An acceptable thesis is required for the degree unless waived by the Chairman, Department of Aeronautics, in which case 10 quarter hours of 4000 level courses in the disciplines of engineering, physical science, or mathematics will be required in addition to those specified above, increasing the total requirement to 46 quarter hours of graduate level credits.

## AERONAUTICAL ENGINEER

Upon completing the preparatory courses, students may be selected on the basis of academic performance for the program leading to the degree Aeronautical Engineer. Selection to this degree program shall be limited to those students who, in the opinion of the faculty, have the potential to conduct the required research. The degree Aeronautical Engineer requires a minimum of 72 credit hours of graduate courses, of which at least 48 credit hours shall be at the 4000 level. It also requires that not less than 64 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 36 hours of courses in the Department of Aeronautics and a minimum of 12 hours in other departments. An acceptable thesis is required for the degree.

Students admitted to work for the degree Aeronautical Engineer may be satisfying requirements for the Master of Science degree concurrently. The Master of Science in Aeronautical Engineering may be conferred at the time of completion of the requirements for that degree.

## DOCTORATE

The Department of Aeronautics offers programs leading to the doctorate in the fields of gasdynamics, flight structures, flight dynamics, propulsion and aerospace physics.

Entrance into the doctorate program may be requested by officers currently enrolled who have sufficiently high standing. The Department of Aeronautics also accepts officer students selected in the Navy-wide Doctoral Study Program, and civilian students selected from employees of the United States federal government.

All applicants who are not already enrolled as students in the Department of Aeronautics shall submit transcripts of their previous academic and professional records and letters of recommendation to the Department Chairman. The Chairman, with the advice of other department members, shall decide whether to admit the applicant to the Doctoral Program.

Every applicant who is accepted for the Doctoral Program will initially be enrolled in the AeE Program under a special option which satisfies the broad departmental requirements for the Engineer's degree and which includes research work. As soon as feasible, the student must find a faculty adviser to supervise his research and help him initially in the formulation of his plans for advanced study. As early as practicable thereafter, a Doctoral

Committee shall be appointed to oversee that student's individual Doctoral Program as provided in the school-wide requirements for the Doctor's degree.

The degree requirements are as outlined under the general school requirements for the Doctor's degree.

In the event that a student is unable finally to satisfy the above requirements for the doctorate for any reason but has in the course of his doctoral studies actually completed all of the requirements for the degree of Aeronautical Engineer, he shall be awarded the latter degree.

## AERONAUTICAL LABORATORIES

Five major laboratory divisions facilitate instructional and research programs in subsonic aerodynamics, structural test, rocket propulsion, turbomachinery, and gasdynamics.

The subsonic aerodynamics laboratory consists of two low-speed, continuous flow wind tunnels and a large continuous flow visualization tunnel. Standard techniques are used in the 32 x 45 inch and 42 x 60 inch wind tunnels to study basic fluid flow about bodies, stability and control of flight vehicles, and unsteady flows about bluff bodies and lifting surfaces. Helium bubble filaments are used in the 5 x 5 x 12 foot test section in the three-dimensional flow visualization tunnel to define flow fields of interest, e.g. about helicopter blades, and jet-flap flow.

The structural test laboratory contains testing machines for static and dynamic tests of materials and structures, and an electro-hydraulic closed-loop machine for fatigue testing. Aircraft components as large as complete aircraft wings are accommodated on a special loading floor, where static and vibration tests are conducted. A well-equipped dynamics laboratory contains shaker tables, analog computers, and associated instrumentation. An adjacent strain gage and photoelastic laboratory provides support to test programs and instruction in structural testing techniques.

The rocket laboratory consists of an instrumented control room, a propellant chemistry laboratory, a high pressure air facility, and three test cells. The test cells are equipped for investigating solid, liquid, gaseous, and hybrid rocket combustion, and for studies of the internal ballistics of small caliber cannon. A solid fuel ramjet test facility is also in operation.

The turbopropulsion laboratory houses advanced facilities for engine and engine component research and development in a complex of especially designed concrete structures. One building, powered by a 750 HP compressor, contains a 10" by 60" rectilinear cascade windtunnel and a large three stage axial research compressor for low speed studies. A second building, powered by a 1200 HP compressed air plant, contains fully instrumented transonic turbine and compressor test rigs in explosion proof test cells. A spin-pit for structural testing of rotors to 50,000 rpm and 1800°F is provided. Model experiments and equipment for instrumentation development are located in a separate laboratory. Data acquisition from 200 channels of steady-state and 16 channels of non-steady measurements at up to 100 kHZ is controlled by the laboratory's HP 21MX computer system. On-line reduction and presentation of data and multiple-user operation

under time sharing, are available.

The gas dynamics laboratory includes a 4 x 4 inch blowdown supersonic wind tunnel, a cold-driven, three-inch double-diaphram shock tube, and a 2 x 2 x 18 foot open-circuit oscillating flow wind tunnel. Laser interferometers, schlieren systems, and hotwire anemometers are used for flow observations. Ruby, He-Ne, argon, and $CO_2$ lasers are available; extensive use is made of laser holography. An electrohydrodynamic research facility permits studies of electric power generation and turbulence. A coaxial plasma accelerator has recently been completed.

In addition to the major laboratory facilities, which includes extensive instrument development and data processing capabilities, there are ballistic ranges for studies of topics such as aircraft vulnerability, a composite materials fabrication laboratory, and a number of flight simulators used with hybrid computers and graphic displays in studying pilot/control system interactions. The department also operates a three-ton surface effect ship testcraft.

## AERONAUTICS

**AE 0010 Aeronautical Engineering Seminar (0-1).**
Oral presentations of material not covered in formal courses. Topics cover a wide spectrum of subjects ranging from reports of current research to survey treatments of fields of scientific and engineering interest.

**AE 0020 Aeronautical Engineering Program Planning (0-1).**
Oral presentations by the Aeronautics Academic Associate and faculty members involved in research with Aeronautics students on program planning, thesis requirements and research specialty areas. The course is to be given to each input during second quarter on board.

**AE 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

### *Upper Division Courses*

A number of preparatory courses in Aeronautics are available through the Continuing Education Division. These one-credit hour minicourses have been prepared in a self-instructional mode (PSI) and complete descriptions for each minicourse may be found in the Continuing Education catalog. The minicourses are equivalent to, and may be substituted for, the on-campus courses as follows:

| Campus Course | Equivalent PSI Sequence |
|---|---|
| AE 2015 | AE 2001 through 2004 |
| AE 2025 | AE 2101 through 2106 |
| AE 2035 | AE 2301 through 2304 |
| AE 2036 | AE 2305 through 2308 |
| AE 2045 | AE 2401 through 2406 |

**AE 2015 Engineering Dynamics (3-2).**
Fundamental physical concepts; dynamics of particles and of systems of particles; concepts of work-energy and impulse-momentum; rigid body dynamics; the inertia tensor and Euler's equations. Introduction to vibration theory and to the analytical, Lagrangian formulation of dynamics. (*May be taken through Continuing Education as Minicourse sequence AE 2001-04*)*

**AE 2025 Introduction to Flight Structures (5-2).**
Reviews basic principles of statics. Introduction to concepts of stress and strain, and mechanical behavior of materials. Bending and torsional stress and deflection analysis of representative aero-structural components, including statically indeterminate cases. Introduction to stability analysis, and energy methods. (*May be taken through Continuing Education as the minicourse sequence AE 2101-06*)*

**AE 2035 Basic Aerodynamics (3-2).**
Dimensional analysis, elements of two-dimensional ideal fluid flow, Kutta-Joukowski law, thin airfoil theory, finite wing theory. (*May be taken through Continuing Education as the minicourse sequence AE 2301-04*)*

**AE 2036 Performance and Stability (3-2)**
Model atmosphere; defined airspeeds; aircraft performance including climb, range, endurance and energy management; principles of longitudinal, lateral and directional static stability of aircraft. (*May be taken through Continuing Education as the minicourse sequence AE 2305-08*)*

**AE 2045 Fundamentals of Thermo-Gasdynamics (5-2).**
Properties of fluids. Principles of continuity, momentum, and energy for incompressible and compressible fluids; control volume formulations. Second law of thermodynamics, entropy and irreversibilities; equations of state, properties of pure substances; power cycles. Viscous flows, boundary layer concepts. Compressible flows, adiabatic/isentropic flow; normal shocks, moving and oblique shocks, Prandtl-Meyer flow. (*May be taken through Continuing Education as the minicourse sequence AE 2401-06*)*

*The minicourses are described in the Continuing Education catalog.

**AE 2811 Aeronautical Laboratories I (0-2).**
A six-week course containing selected experiments in aero-structures. PREREQUISITE: AE 2025 *Graded on Pass/Fail basis only.*

**AE 2812 Aeronautical Laboratories II (0-2).**
A six-week course containing selected experiments in dynamics. PREREQUISITE: AE 2015. *Graded on Pass/Fail basis only.*

**AE 2813 Aeronautical Laboratories III (0-2).**
A six-week course containing selected experiments in subsonic fluid flow. PREREQUISITES: AE 2035, 2036. *Graded on Pass/Fail basis only.*

**AE 2814 Aeronautical Laboratories IV (0-2).**
A six-week course containing selected experiments in supersonic fluid flow. PREREQUISITE: AE 2045. *Graded on Pass/Fail basis only.*

*Upper Division or Graduate Courses*

AE 3005 Survey of Aircraft & Missile Technology: Concepts and Applications (4-0).
(For Non-Aeronautical Engineering students.)
A course designed to familiarize the student with the conceptual basis of military applications of technology of high performance aircraft, V/STOL configurations, strategic and tactical missiles, etc. PREREQUISITES: SECRET clearance and consent of Instructor.

AE 3251 Aircraft Survivability/Vulnerability (3-2).
This course brings together all of the essential ingredients in a study of the survivability and vulnerability of fixed wing and rotary wing aircraft in a hostile environment. Topics to be covered include: actual SEA and Mid-East Losses — how many and why; the threat environment — small arms, AAA, SAM, AAM, lasers; S/V assessment methodology — the mission, aircraft description, vulnerability analysis, probability of kill, trade-off studies; survivability enhancement — minimize detection, aircraft design ECM, tactics; vulnerability reduction — design improvements for fuel systems, flight controls, structures and materials, crew protection and the electrical system. In-depth S/V studies of the A-7, A-10, F-16, F-18, and P-3 will be presented. PREREQUISITES: SECRET clearance, U.S. Citizenship, and consent of Instructor.

AE 3305 V/STOL Aircraft Technology (3-2).
(For Non-Aeronautical Engineering students)
Basic aerodynamic and propulsion principles and phenomena, past and current vertical take-off and landing aircraft developments, current technology status and problems, U.S. Navy V/STOL aircraft requirements and acquisition programs, Russian V/STOL aircraft and assessment of USSR-V/STOL aircraft technology and trends, impact of VSTOL aircraft technology on naval systems acquisition and operations. PREREQUISITE: Consent of Instructor.

**AE 3815 Advanced Aeronautical Laboratories (0-3).**
Selected experiments emphasizing modern instrumentation techniques in the areas of gas dynamics, propulsion, structures, and flight dynamics. PREREQUISITE: Aero Preparatory Phase or equivalent.

**AE 3900 Special Topics in Aeronautics (Variable credit up to five hours).**
Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman

*Graduate Courses*

**AE 4101 Flight Vehicle Structural Analysis (3-2).**
Graduate core course in structures covering basic definitions and field equations for solid bodies, two-dimensional stress and analysis, thin skin and thick skin wing bending analysis, fracture and fatigue theory. PREREQUISITE: Aero Preparatory Phase or equivalent.

**AE 4102 Advanced Aircraft/Missile Structural Analysis (3-2).**
The finite element method of structural analysis will be studied and applied to aircraft and missile structures. Capabilities of the current finite element computer programs will be discussed. An introduction to the theory of structural dynamics and stability will also be presented. PREREQUISITE: AE 4101.

**AE 4103 Advanced Aircraft Construction (4-0).**
A course covering the manufacturing techniques and analysis of composite materials and sandwich construction. Theories of failure, damage and repair. Advanced design concepts. PREREQUISITE: AE4101.

**AE 4271 Design Problems In Aeronautics I (3-3).**
A complex engineering problem in the field of flight vehicles is presented for solution by systems-oriented methods, with the primary purpose of developing basic understanding for the design process. Integration of various disciplines, evaluation of airworthless requirements, real-life complexities, and team work with clearly assigned responsibilities are emphasized. PREREQUISITE: Completion of the Aero Graduate Core.

**AE 4272 Design Problems In Aeronautics II (3-3).**
Continuation of AE 4271.

**AE 4273 Subsonic Aircraft Design (3-2).**
The course centers on a preliminary design project individually formulated by each student to meet given specifications. The end product is a three-view supported by aerodynamic design calculations. PREREQUISITE: Completion of the Aero Graduate Core.

**AE 4274 Computerized Aircraft Design & Design Evaluation (3-2).**
Beginning with a baseline airplane from AE 4273, ACSYNT, a large design program, is used to converge a vehicle for several specified missions and then to optimize it. A preliminary design is made of the optimized vehicle, and the final project is a design evaluation. PREREQUISITE: AE 4273.

**AE 4301 Stability and Control of Aerospace Systems (3-2).**
Equations of motion, stability derivatives; short period, phugoid, roll, spiral and Dutch roll modes. Transfer functions, Bode plots. Connections with static stability and handling quality criteria. Linear feedback systems, Root locus method, synthesis criteria; relation between time and frequency domain. Analysis of airplane plus pilot, synthesis of stability augmentation systems, autopilot loop synthesis. PREREQUISITE: Aero Preparatory Phase or equivalent.

**AE 4305 V/STOL Aircraft Technology (3-2).**
Types of V/STOL aircraft, fundamental principles, main performance characteristics and propulsion requirements, STOL technology: mechanical high-lift devices, powered-lift devices, jet flaps, autmentor wings; VTOL technology: flow vectoring devices, lift engine and lift fan technology, augmentor wings; airframe/propulsion system interactions, ground interference effects: V/STOL stability and control considerations, hanling qualities; review of current development programs, NAVY V/STOL requirements and programs. PREREQUISITE: Aero Graduate Core or permission of Instructor.

**AE 4310 Status, Trends and Uncertainities In Aerospace Vehicle Design. (4-0).**

Critical analysis of current analytical and testing methods used to design flight vehicles and air weapons. Emphasis is placed on weaknesses in underlying assumptions and inherent uncertainties caused by limited analysis and testing capability available during a typical development program. PREREQUISITE: Aero Graduate Core or permission of Instructor.

**AE 4318 Aeroelasticity (4-0).**
Response of discrete and continuous elastic structures to transient loads and to steady oscillatory loads, utilizing matrix methods. Static aeroelasticity problems in aircraft, nonstationary airfoil theory. Application to the flutter problem. Transient loads, gusts, buffet, and stall fultter. PREREQUISITE: AE 4301.

**AE 4323 Flight Evaluation Techniques (3-2).**
Quantitative and qualitative techniques for the evaluation of aircraft performance and handling qualities of flight; aircraft data acquisition systems; normalizing and standardizing of flight test data; pilot rating scales; effects of design parameters; application of specifications to flight evaluations. PREREQUISITE: AE 4301 or equivalent.

**AE 4342 Advanced Control For Aerospace Systems (3-2).**
State variable analysis including state variable feedback and state variable estimators (observers). Optimal control; digital fly-by-wire systems. Topics from non-linear systems and/or stochastic control. PREREQUISITE: AE 4301.

**AE 4431 Aerothermodynamics & Design of Turbo machines (3-3).**
Fundamental laws for flow and energy exchange in compressors and turbines, and current engineering methods for their aerodynamic design, test and measurement. PREREQUISITE: AE 4451.

**AE 4451 Aircraft and Missile Propulsion (3-2).**
Description, design criteria, analysis, and performance of solid propellant rockets, ramjets, turboprops, turbojets and turbofans. Analysis of components: inlets, compressors, combustors, turbines and nozzles. Current state-of-the-art and impact of trends in propulsion technology. PREREQUISITE: Aero Preparatory Phase or equivalent.

**AE 4452 Rocket and Missile Propulsion (4-0).**
Applications and analysis of propulsion devices for tactical weapons systems. Systems considerations and trade-offs. Introduction to multistage rockets. Combustion temperature, product composition, kinetics, smoke, detonation sensitivity, pollution. Review of current exploratory development programs. PREREQUISITE: AE 4451.

**AE 4501 Current Aerodynamic Analysis (3-2).**
Introduction to current aerodynamic analysis methods for subsonic, transonic and supersonic flight vehicles. Developments proceed from the three-dimensional Navier-Stokes equations to various approximation methods, such as linearized, inviscid subsonic and supersonic panel methods for wing-body combinations, laminar and turbulent boundary layer analyses and introduction to transonic flow. PREREQUISITE: Aero Preparatory Phase or equivalent.

**AE 4502 High-Speed Aerodynamics (4-0).**
Topics include linearized surface theory for subsonic and supersonic aircraft in both steady and unsteady motion, nonlinear transonic and supersonic flow theory and solutions by characteristics, relaxation and timemarching methods; boundary layer computations, shock-boundary layer interactions and separated flow effects. Applications include the discussion of sweep-back effect, area rule, supercritical airfoils, controlled vortex lift, blended wingbody designs etc., on aircraft performance. Also, selected internal flow problems are discussed. PREREQUISITE: AE 4501.

**AE 4503 Missile Aerodynamics (4-0).**
The aerodynamics of missiles and guided projectiles for various speed regimes and motions. Topics include slender body and linearized theory as well as nonlinear aerodynamic effects, coupling effects, Magnus effects, etc. The impact of these effects on missile flight dynamics, guidance and control is included. PREREQUISITE: AE 4501.

**AE 4505 Laser Technology (3-2).**
Survey of different types of lasers, including gaseous, solid state, gasdynamic and chemical lasers, resonator cavities, gaussian beams and propagation mechanisms; high energy lasers and military applications of lasers. PREREQUISITE: Consent of Instructor. (May also be taught as ME 4505)

**AE 4632 Computer Methods In Aeronautics (3-2).**
Use of the digital computer in numerical methods. Classification of Aeronautical Engineering problems as equilibrium, eigenvalue or propagation problems. Computer solution procedures developed for the ordinary and partial differential equations of gas dynamics, heat transfer, flight mechanics and structures. PREREQUISITE: Aero Preparatory Phase or equivalent.

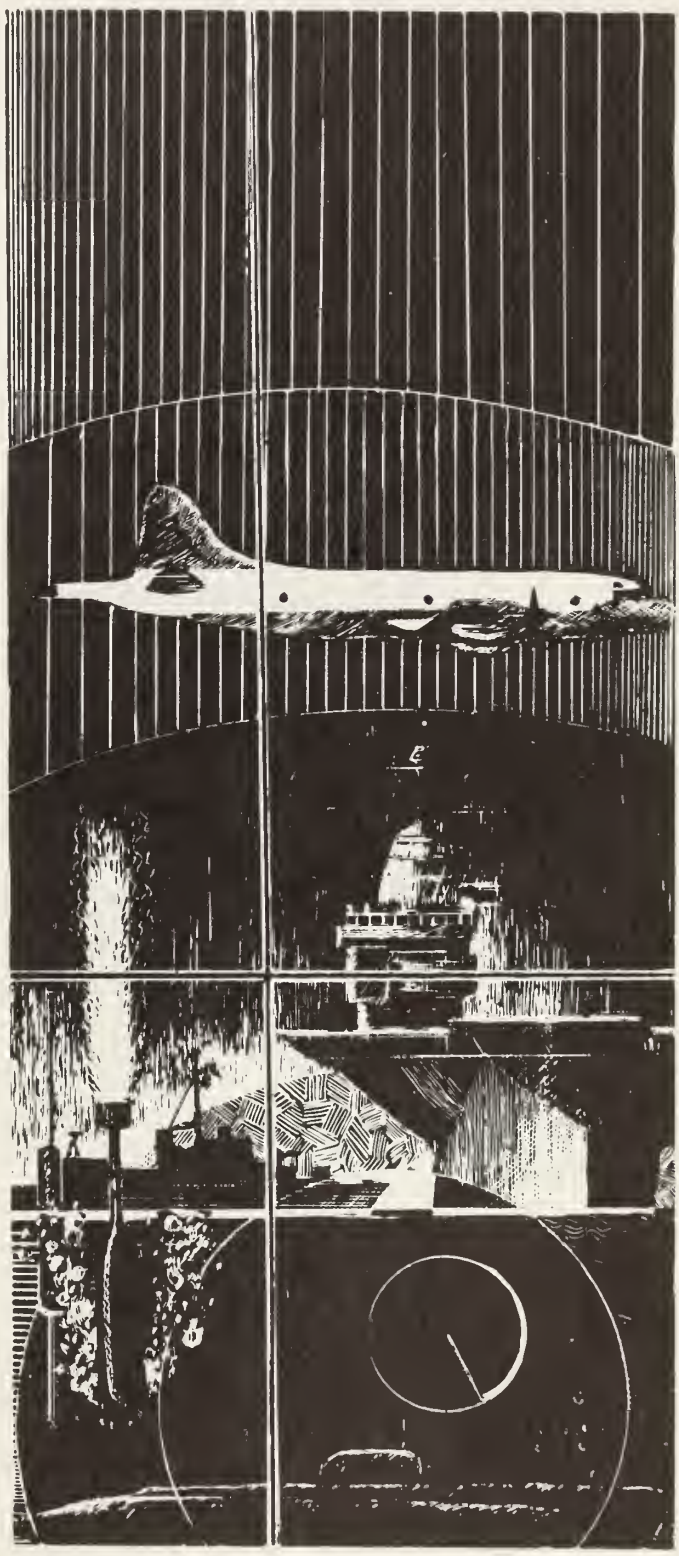
**AE 4641 Aeronautical Data Systems (3-2).**
A design-project-oriented course utilizing microprocessor technology with emphasis upon aeronautical engineering applications. Both software and hardware aspects of system integration will be considered for engineering tradeoffs during problem definition and solution. PREREQUISITE: EE 2810 or equivalent.

**AE 4900 Advanced Study In Aeronautics (Variable credit up to five hours).**
Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman.

*Doctoral Recipient*

# ANTISUBMARINE WARFARE

The Antisubmarine Warfare Academic Group has administrative responsibility for the academic content of the Antisubmarine Warfare Program. Teaching in this program is carried out by faculty members attached to the various Academic Departments associated with the Program.



**Robert Neagle Forrest**, Associate Professor of Operations Research; Chairman (1964)*; B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

**Donald Charles Daniel**, Assistant Professor of Political Science (1975); B.A. Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

**John Norvell Dyer**, Professor Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

**Carl Russell Jones**, Professor of Administrative Sciences (1965); B.S., Carnegie Institute of Technology; 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

**George Lawrence Sackman**, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D., Stanford Univ., 1964.

**Warren Charles Thompson**, Professor of Oceanography (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institute of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

**Alan Robert Washburn**, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

**Carroll Orville Wilde**, Professor of Mathematics (1968); B.S., Illinois State

Univ., 1958; Ph.D., Univ. of Illinois, 1964.

**Oscar Bryan Wilson, Jr.**, Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

## MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master Science in Systems Technology will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements;

a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included and in three disciplines, a course at the 4000 level must be included.

b. An approved sequence of at least three courses constituting advanced specialization in an option area must be included.

c. In addition to the 45 hours of course credit, an acceptable group project or thesis must be completed.

d. The program must be approved by the Chairman of the ASW Group.

### SYSTEMS TECHNOLOGY

**ST 0001 Seminar (0-1).**
Special lectures, and discussion of matters related to the ASW Program. PREREQUISITE: SECRET clearance.

**ST 0810 Thesis Research/Group Project (0-0).**
Students in the Systems Technology curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

**ST 1810 Introduction To Programmable Calculators (1-1).**
Programming and use of keyboard functions, data storage and retrieval, printers, plotters, subroutine packages. This course is designed for students in the Antisubmarine Warfare and Weapons Engineering curricula. PREREQUISITE: None. **Graded on Pass/Fail basis only.**

*Upper Division or Graduate Course*

**ST 3000 Study Project On ASW Systems Performance (0-2).**
This project is the study and analysis of the performance of an assigned type of ASW system under a variety of realistic operating conditions. *Graded on a Pass/Fail basis.* PREREQUISITE: Enrollment in ASW curriculum or consent of curriculum coordinator, SECRET clearance.

# AVIATION SAFETY PROGRAMS

**Robert Lewis**, Captain, U.S. Navy; Director (1978)*; B.A., Naval Postgraduate School, 1966; M.A., George Washington Univ., 1975: ED.S. 1977.

**Milton Harold Bank, II**, Assistant Professor of Aeronautics (1971); B.S., U.S. Naval Academy, 1957; B.S.A.E., Naval Postgraduate School, 1964; Engr., Stanford, 1967; M.S. Georgia Institute of Technology, 1970; Ph.D., 1971.

**Russell Branson Bomberger**, Professor of Law and Psychology (1958); B.S., Temple Univ., 1955; L1.B., LaSalle Univ., 1968; J.D., 1969; M.A. Univ. of Iowa, 1956; M.S., Univ. of Southern California, 1960; M.A., Univ. of Iowa, 1961; Ph.D., 1962.

**Craig Merrill Bradbury**, Commander, U.S. Navy; Instructor in Advance Safety Management and Aircraft Accident Investigation (1976); B.S., Naval Postgraduate School, 1963.

**John Robert Johnson**, Lieutenant Commander; U.S. Navy; Instructor in Safety Program Management and Aircraft Accident Prevention (1976); B.A., Drury College, 1960.

**Edward John Kennedy**, Associate Professor of Aviation Physiology (1972); M.D., Univ. of Iowa College of Medicine, 1962.

**Ronald John Laib**, Lieutenant Commander, U.S. Navy; Instructor in Aeronautical Engineering and Safety (1977); B.A., Concordia College, 1963; M.S., Naval Postgraduate School, 1971.

**George Edward Tucker**, Captain, U.S. Marine Corps; Instructor in Aeronautical Engineering and Safety (1977); B.S., U.S. Naval Academy, 1968.

**Lewis Edward Waldeisen**, Commander; U.S. Navy; Assistant Professor of Operations Research for Human Factors Engineering (1974); B.S., Univ. of San Francisco, 1960; M.A., Univ. of New Mexico, 1965; Ph.D., Texas Tech Univ., 1974.

**Lester Charles Wible**, Assistant Professor of Aviation Accident Prevention and Crash Investigation (1965); B.S., U.S. Naval Academy, 1945.

**The year of joining the Postgraduate School Faculty is indicated in parenthesis.*

## AVIATION SAFETY OFFICER COURSE

An Aviation Safety Officer (ASO) course is offered eight times per year on a temporary additional duty basis for those commands needing a trained Safety Officer/Aviation Safety Officer. The course prepares safety officers at the squadron level to assist commanding officers in conducting an aggressive accident prevention program. When the SO/ASO completes this course he will be able to organize and administer an accident prevention program at the squadron level as defined in OPNAVINST 5100.8.

This 6 week course consists of approximately 185 classroom hours of safety program management, including mishap prevention techniques, operational aerodynamics and aircraft structures, mishap investigation and reporting, psychology, law, and aeromedical support. Prior completion of college level courses in algebra and/or physics is highly desirable. Two class field trips will be conducted: A safety survey of an operating squadron or air station; and an

industrial activity tour.

Designated naval aviators and naval flight officers of the Navy and Marine Corps of the rank of Lieutenant, USN, and Captain, USMC, and above are eligible to attend. Exceptions must be approved by Type Commanders, or CMC, as appropriate. Details of quota control and class schedules are defined in CNETNOTICE 1520.

## ADVANCED SAFETY MANAGEMENT COURSE

The Advanced Safety Management (ASM) course is designed to provide additional safety education beyond the SO/ASO level for officers assigned to major aviation staffs, the Naval Safety Center, and Navy/Marine Corps air stations.

This course consists of approximately 125 classroom hours of such subjects as safety management concepts, safety program analysis, Military Standard 882A, statistical decision making, human factors engineering, psychology, law, and industrial safety including occupational Safety and Health Act concepts. A field trip to an airline maintenance base will be conducted.

Enrollment in the ASM course is limited to officers currently occupying staff aviation safety billets or proceeding to such duty. A prerequisite for the ASM course is completion of either the ASO course, the former Survey of Aviation Safety course, or at least one year's experience in a safety billet. Eligible officers without this prerequisite should be ordered to attend both the ASO and ASM courses. Details of quota control and class schedules are defined in CNET NOTICE 1520.

## RESIDENT COURSES

Officers regularly enrolled in other curricula of the Postgraduate School may qualify for the Aviation Safety Officer Certificate by completing the program requirements: AO 2020, AO 2030, AO 3000, AO 3050, and AO 3060. Substitutions for some of these courses may be made by taking equivalent courses in other departments upon approval of the Director of Aviation Safety. Examples: AO 2020 may be replaced by upper division or graduate courses in aeronautical engineering covering similar topics. AO 3040 may be replaced by upper division or graduate courses in psychology covering similar topics.

Officers regularly enrolled in other curricula of the Postgraduate School may qualify for the Advanced Safety Management Certificate by completing ASM program requirements. Prospective ASM candidates must have completed the Aviation Safety Officer program described above, or its equivalent, prior to enrolling in ASM course. Specific ASM course requirements include AO 3100 and AO 3120.

## AVIATION SAFETY COMMAND COURSE

The Aviation Safety Command (ASC) course is offered seven times a year on a temporary additional duty basis to commanding officers, executive officers, OinC's and officers screened for aviation command. This course consists of approximately 41 hours of such subjects as safety program management, safety psychology, aviation law, aircraft systems, and incidents/accident endorsements. No academic credit is available for this course.

## AVIATION

*Upper Division Courses*

**AO 2020 Aerodynamics For Aircraft Accident Prevention and Investigation (3-0).**
Survey of aerodynamics, performance, stability and control of flight vehicles. Critical areas of operation, contribution of operator techniques, effects of varying configurations, design deficiencies, and manufacturing defects.

**AO 2030 Aircraft Structural Analysis (1-0).**
Strength of materials, design criteria, failure mechanisms. Recognition of failures, fatigue, brittle fractures, contribution of manufacturing and maintenance, analysis of evidence, corrosion control technology, and quality control concepts.

*Upper Division or Graduate Courses*

**AO 3000 Problems In Accident Prevention And Investigation (0-4).**
Problem-solving exercises in the application of systems safety concepts in the organization of squadron accident prevention and investigation effort. Developed primarily through case-study methods, the course emphasizes conservation of resources, cost effectiveness, and systems management in accident prevention, investigation, and reporting.

**AO 3040 Safety Psychology (1-0).**
Study of human reliability in survival-value environments; personality elements in safety motivation; identification and reduction of problems in human reliability.

**AO 3050 Safety Law (1-0).**
Study of leading cases and statutes concerning rights and duties in the safety disciplines. Emergency claims; quasicontractural duties. Criminal prosecution of safety violations. Legal duties of care. Special rules of evidence used by the courts in safety-related disputes.

**AO 3060 Problems In Aviation Medicine (1-0).**
Life-science considerations in accident prevention and investigation. Medical prediction. Effects of hypoxia, dysbarism, G-forces, spatial disorientation, diet, drugs, and exercise upon flight capabilities. Recognition of emotional difficulties; emotional considerations in accident-prevention. Interpretation of autopsy reports.

**AO 3100 Management Of Accident-Prevention Programs (3-2).**
Management theories, practices, communications, and controls; automatic data-processing and analysis of accident statistics; legal consideration in safety management; use of systems safety in hazard identification.

**AO 3120 Technological Aspects of Accident-Prevention and Analysis (3-2).**
Topics include case studies of technological design-related aviation mishaps; identification of structural failure modes; computer and simulator methods in aeronautics; safety-related problems of Navy weapons-system evaluation and acquisition.

# COMMAND, CONTROL AND COMMUNICATIONS (C3)

*C3 Exercise Laboratory*

The Command, Control and Communications Academic Group has administrative responsibility for the academic content of the Command, Control and Communications program. Teaching in this program is carried out by faculty members attached to the various academic departments associated with the program.

**John McReynolds Wozencraft,** Professor of Electrical Engineering; Chairman (1977)*; B.S., U.S. Military Academy, 1946; S.M. and E.E., Massachusetts Institute of Technology, 1951; Sc.D., 1957.

**Robert Ward Burton,** Lieutenant Colonel, U.S. Air Force; Associate Professor of Electrical Engineering (1973); B.S., U.S. Naval Academy, 1955; S.M. (E.E.), Massachusetts Institute of Technology, 1960; E.E., 1960; Ph.D., Harvard Univ., 1964.

**Donald Paul Gaver, Jr.,** Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D., Princeton Univ., 1956.

**Francis Richard Murphy,** Lieutenant Colonel, U.S. Air Force; Instructor in Computer Science (1977); B.S., Florida Southern College, 1966; M.C.S., Texas A&M Univ., 1969.

**Samuel Howard Parry,** Associate Professor of Operations Research (1973); B.S., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

**Gary Kent Poock**, Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

**George Anthony Rahe**, Professor of Electrical Engineering and Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

**Francis Russell Richards**, Associate Professor of Operations Research (1970); B.S., Louisiana Polytechnic Institute, 1965; M.S., Clemson Univ., 1967; Ph.D., 1971.

**Ronald Jay Roland**, Lieutenant Colonel, U.S. Air Force; Instructor in Computer Science (1976); B.S., Colorado State Univ., 1969; M.S., Univ. of Hawaii, 1971; A.B.D., Univ. of Nebraska, 1977.

**Michael Graham Sovereign**, Professor of Operations Research, (1970); B.S., Univ of Illinois, 1959; M.S., Purdue Univ., 1960; Ph.D., 1965.

**Robert Donald Yingling**, Captain, U.S. Air Force; Instructor in Electrical Engineering (1977); B.S.E.E., Oklahoma State Univ., 1967; M.S.E.E., Massachusetts Institute of Technology, 1968.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

### *MASTER OF SCIENCE IN OPERATIONAL DECISION SYSTEMS*

The degree of Master of Science in Operational Decision Systems will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements:

a. The Master of Science in Operational Decision Systems requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level.
b. In addition to the 45 hours of course credit, an acceptable thesis must be completed.
c. The program must be approved by the Chairman of the Command, Control and Communications Academic Group.

# DEPARTMENT OF COMPUTER SCIENCE

*Computer Laboratory on the fifth deck of Spanagel Hall.*

**Gordon Hoover Bradley**, Professor of Computer Science; Chairman (1973)*; B.S., Lehigh Univ., 1962; M.S., 1964; Ph.D., Northwestern Univ., 1967.

**Gerald Gerard Brown**, Associate Professor of Operations Research and Computer Science (1973); B.A., California State Univ. at Fullerton, 1968; M.B.A., 1969; Ph.D., Univ. of California at Los Angeles, 1974.

**Franklin Burkhead**, Lieutenant Commander, U.S. Navy; Instructor in Computer Science (1977); B.S., U.S. Naval Academy, 1966; M.S., Naval Postgraduate School, 1977.

**Richard Wesley Hamming**, Adjunct Professor of Computer Science (1976); B.S., Univ. of Chicago, 1937, M.S., Univ. of Nebraska, 1939; Ph.D., Univ. of Illinois 1942.

**Stephen Trygve Holl**, Lieutenant Commander, U.S. Navy; Assistant Professor of Computer Science (1976); B.S. U.S. Naval Academy, 1967; Ph.D., The John Hopkins Univ., 1974.

**Cynthia Emberson Irvine**, Adjunct Research Instructor (1975); B.A. Rice Univ., 1970; Ph.D., Case Western Reserve Univ., 1975.

**Gary Arlen Kildall**, Associate Professor of Computer Science and Mathematics (1972); B.S. Univ. of Washington, 1967; M.S., 1968; Ph.D., 1972.

**Uno Robert Kodres**, Associate Professor of Mathematics and Computer Science (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

**Robert Steele McCormack**, Lieutenant

Commander, U.S. Navy; Instructor in Computer Science (1978); B.S., San Diego State Univ., 1964; M.S., Naval Postgraduate School, 1977.

**Neil Patrick Miller,** Lieutenant Colonel, U.S. Marine Corps; Instructor in Computer Science and Administrative Sciences (1976); B.A., Univ. of California at Berkeley, 1956; B.A., Southern Colorado State College, 1965; M.S., Naval Postgraduate School, 1966.

**Mark Sheridan Moranville,** Lieutenant, U.S. Navy, Instructor in Computer Science (1977); B.S., Oregon State Univ. 1972; M.S., Naval Postgraduate School, 1977.

**Francis Richard Murphy,** Lieutenant Colonel, U.S. Air Force; Instructor in Computer Science (1977); B.S., Florida Southern College, 1966; M.C.S., Texas A&M Univ., 1969.

**George Anthony Rahe,** Professor of Electrical Engineering and Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

**Roland Jay Roland,** Lieutenant Colonel, U.S. Air Force, Instructor in Computer Science (1976); B.S., Colorado State Univ., 1969; M.S., Univ. of Hawaii, 1971; A.B.D., Univ. of Nebraska, 1977.

**Norman Floyd Schneidewind,** Professor of Computer Science and Information Science (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## MASTER OF SCIENCE IN COMPUTER SCIENCE

1. The degree of Master of Science in Computer Science will be awarded upon the satisfactory completion of a program, approved by the Chairman, Computer Science Department, which satisfies, as a minimum, the following degree requirements:

   A. At least 40 quarter hours of graduate level work of which at least 12 quarter hours must be at the 4000 level.

   B. The program shall include at least:

| | Quarter Hours |
|---|---|
| Computer Science | 20 |
| Operations Research, Electrical Engineering, and/or Management. | 9 |
| Mathematics, Probability, and Statistics | 11 |

   C. Completion of an approved sequence of courses constituting specialization in an area of Computer Science.

   D. Completion of an acceptable thesis in addition to the 40 quarter hours of course work.

## LABORATORY FACILITIES

The Computer Science Department has cognizance over the Postgraduate School's Computer Laboratories. The Signal Processing Laboratory is an interconnected computer complex consisting of a medium sized digital computer, two high performance interactive display systems, a large general purpose hybrid/analog computer and multiple terminals and display equipment. Two PDP-11/50 computers and a CSPI-125 signal processing computer have been combined into a multiprocessing system which supports four different types of displays and sixteen time sharing terminals. A Military Systems Laboratory features a general purpose computer capable of emulating current military hardware such as AN/UYK-7 and AN/UYK-20 computers. The Microcomputer Laboratory consists of a variety of microprocessors; included among these are multiple Intellec 8-80 systems supported by floppy-disk units and a Sycor System supporting four time-sharing terminals. All of the above facilities are available school-wide for hands-on use in instruc-

tional and research programs. In addition, the computational resources of the W.R. Church Computer Center provides support for time-sharing and batch processing.

## COMPUTER SCIENCE

**CS 0001 Seminar (0-1).**
Special lectures; guest lecturers; discussion of student thesis research faculty research projects. PREREQUISITE: None.

**CS 0110 Fortran Programming (3-0).**
The basic elements of FORTRAN are covered. Practical application of the principles is afforded by means of a series of problems of increasing difficulty.

**CS 0113 COBOL Programming (3-0).**
The basic elements of COBOL are covered. Practical application of principles is afforded by means of a series of problems of increasing difficulty. Television lectures.

**CS 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

### *Lower Division Courses*

**CS 1500 Introduction To Digital Methods (2-2).**
Programming a keyboard calculator. Data storage and retrieval, printers, plotters and subroutines. Elements of digital systems and digital control of experiments with attention to I/O processes and program control. PREREQUISITE: None.

**CS 1510 FORTRAN Programming Laboratory (1-2).**
The basic elements of FORTRAN for students with experience on a programmable keyboard calculator. Practical applications of the principles are afforded by means of a series of test problems of increasing difficulty. PREREQUISITE: CS 1500. Graded on Pass/Fail basis only.

### *Upper Division Courses*

**CS 2010 Introduction To Computers and Data Processing For Non-Computer Science Major (2-0).**
An introduction to the general characteristics of contemporary computers and to the functions they serve in a diversity of organizations, emphasizing the capabilities of the computer, the limitations of computing and the economics of data processing in general. There are no prerequisite or corequisite courses. Prior computing experience is not assumed and programming is not taught.

**CS 2100 Introduction To FORTRAN Programming (1-2).**
This course is designed to provide the student with a basic familiarity in FORTRAN. The course is intended for the student who is already familiar with programming in a higher level language. PREREQUISITE: CS 2110, CS 2010, or consent of Instructor. Graded on Pass/Fail basis only.

**CS 2102 Introduction To Programming In COBOL (1-2).**
This course is an introduction to programming using the COBOL language. The course is designed for the student with no previous programming experience who is already familiar with computer fundamentals. PREREQUISITES: CS 2010, or consent of Instructor. Graded on Pass Fail basis only.

**CS 2103 Introduction To COBOL Programming (1-2).**
This course is designed to provide the student with a basic familiarity in COBOL. The course is intended for the student who is familiar with programming in a higher level language. PREREQUISITE: CS 2110, CS 2010, or consent of Instructor. Graded on Pass/Fail basis only.

**CS 2104 Introduction To Programming in Basic (1-2).**
This course is designed to familiarize the student with the programming languages and is widely used, especially on small computers and time-sharing systems. An introduction to FORTRAN is included. The course is intended for the student who is already familiar with computer fundamentals. PREREQUISITE: CS 2010, or consent of Instructor. Graded on Pass/Fail basis only.

**CS 2105 Survey of Computers and Programming (4-0).**
A general appreciation of computer history, computer system organization, computer applications and computer management. Program design and coding in an algorithmic language. Not recommended for anyone intending to take further courses in computer science. PREREQUISITE: None.

**CS 2107 Introduction to the CMS-2 Computer Language (1-2).**
This course is designed to provide the student with a basic familiarity in CMS-2. The course is intended for the student who is familiar with programming in a higher level language. The course may be taught in either a PSI or self-instructional mode. PREREQUISITE: CS 2110 or consent of Instructor.

**CS 2110 Introduction to Computers and Programming for Computer Science Majors (3-2).**
Algorithmic problem solving. Emphasis on symbol manipulation more than numeric computation. Basics and characteristics of computers and computer solutions of problems. Programming and timesharing systems. Basic machine operations and assembly level programs. PREREQUISITE: None.

**CS 2520 Mathematical Modeling and Simulation (4-0).**
Continuous simulation based mainly on dynamical systems of ordinary differential equations. Discrete simulations including statistical analysis. PREREQUISITES: MA 2121, and CS 1510.

**CS 2600 Introductory Computing and Computer Science for Operations Analysis (2-0).**
An introduction to computer problem solving mehtods for students in the Operations Research curriculum. Topics include subprograms, numerical error control and numerical methods and program organization and debugging. Emphasis is placed on actual computer programming experience with 5-7 operations research related projects of increasing difficulty. Classroom examples and assigned projects are drawn from first quarter Operations Research courses. PREREQUISITES: CS 0110 or experience in FORTRAN programing.

**CS 2700 Introduction To Computer Programming with FORTRAN (2-2).**
An introduction to characteristics of general purpose digital computers, and the fundamentals of algorithmic problem solving emphasizing the flow-charting method. Basic computer programming in the FORTRAN language, primarily directed toward the solution of numerical problems and matrix manipulation, including the use of library subroutines. Students who have taken a previous FORTRAN course (CS 0110, CS 2100 or CS 2600) should not enroll in this course.

*Upper Division or Graduate Courses*

**CS 3010 Computing Devices and Systems (4-0).**
This course will provide a survey of peripheral computer devices, computer memories, the central processing unit and their interaction and means of communication. Consideration will be given to the various arrangements of data in the different storage devices in relation to the writing and retrieving of this data. Specific equipment in the NPS computer center and computer laboratory will be examined in detail in a hands-on environment and circumvention of inoperative units. PREREQUISITE: CT 2000.

**CS 3020 Program Development: Structure, Design, and Languages (3-4).**
This course will provide the student with broad background in the concept, design and development of computer programs. The subject of language selection, program evaluation, testing and debugging, and program documentation will be covered in the lecture portion of the course. The laboratory session will be devoted to the development of programming skills and practices as discussed in the lectures, using the American National Standards Institute COBOL language. Projects assigned during the course will be tested, debugged and run in the NPS computer center. PREREQUISITES: CT 2000, CS 2110 or equivalent background or consent of Instructor.

**CS 3030 Operating Systems Structures (4-0).**
This course will provide a broad overview of operating system including memory management techniques, job scheduling, processor scheduling, device management and data

(information) management techniques. Case studies will be included to illustrate the manager-operating system interfaces, including time usage accounting, error processing and recovery, operating system selection, data control and security, and operating system utility support. In addition future trends in computers will be investigated, including maxi, mini, and microcomputers. PREREQUISITES: CS 3010 and CS 3020 or equivalent background and consent of Instructor.

CS 3111 Fundamental Concepts in Structural Programming Languages (4-0).
An introduction to the significant features of programming languages. Formal definition of a language including specification of syntax and semantics. Characteristics of assemblers, compilers and interpreters. Properties of block structured languages, including scope of declarations, storage allocation and subroutines. Basic programming techniques, including string manipulation, list processing, bit manipulation and recursion. PREREQUISITES: Either CS 2100, CS 2103, CS 2110 or consent of the Instructor.

CS 3112 Operating Systems (4-0).
This course is an introduction to the fundamental concepts of operating systems and system software. Topics to be discussed include multiprogramming, multiprocessing, dynamic relocation, paging, segmentation and virtual memory. Timesharing, process scheduling, system communication and auxiliary storage management are also included. Currently available digital computer systems are compared to demonstrate these concepts. PREREQUISITES: CS 2110 and CS 3111.

CS 3113 Introduction to Compilers (3-2).
This course is intended to explore the basics of modern compiler design and construction techniques. The fundamentals of scanning, grammar based parsing and compiler semantics are developed in the framework of modern compiler-compiler and translator-writing system technology. The laboratory periods will be used to develop a small model compiler/assembler. Modern languages and current NPS research will be used as examples whenever possible. PREREQUISITES: CS 3111 or consent of the Instructor.

CS 3204 Data Communications (4-0).
Quantitative study of communication processes with emphasis on digital communication processes with emphasis on digital communication. Concepts fundamental to the engineering of accurate, efficient communication links and systems. Elements of information theory. Communication channels and their capacity, encoding and decoding of data over noisy channels. Error detection and correction coding schemes and procedures. Techniques and devices for effective data transmission in computer-based systems. PREREQUISITES: EE 2810, PS 3414.

CS 3230 Microcomputers (3-2).
Microcomputer organization. Instruction repertoire. Higher level languages for microcomputers. Interfacing microcomputers with other computer systems and external digital equipment. Systems design using microcomputers as systems elements. The laboratory sessions are devoted to projects which familiarize the student with the practical aspects of systems design. PREREQUISITES: CS 3111, EE 2810 or equivalent.

CS 3300 Information Structures (3-0).
Basic concepts of data. Linear lists, strings, arrays, and orthogonal lists. Representation of trees and graphs. Storage systems and structures, and storage allocation and collection. Symbol tables and searching techniques. Sorting (ordering) techniques. Formal specification of data structures, data structures in programming languages, and generalized data management. PREREQUISITES: CS 3111.

CS 3502 Real-Time Interactive Computer Systems (3-2).
This course presents a study of the hardware and software requirements of real-time, near real-time, and interactive computer systems. Concepts of system software including multiprogramming, multiprocessing, data structures, memory management, and facilities for user-computer interaction are presented. Interrupts, interactive device concepts including graphic displays, data transmission techniques and other hardware support concepts are included. A set of DOD and civilian computer systems will be examined to determine and compare characteristics, effectiveness and system economies of various real-

time computer systems. Introduction to system characteristics is facilitated by laboratory work in which interactive systems are used to demonstrate concepts presented in the classroom. PREREQUISITES: CS 2105, CS 2110, or the equivalent.

**CS 3510 Real-Time Combat Direction Systems and Structures (3-2).**
Basic principles of hardware and software structures and interactions in real-time systems. Operating systems; interrupts, multiprocessing, multiprogramming. Data flow in inter- and intra-computer communication. Operation and management of peripherals. Evaluation and interpretation of component specifications in terms of computer system capabilities. PREREQUISITES: CS 2520 or EE 2810, or CS 2700.

**CS 3601 Automata and Formal Languages (3-0).**
Logical networks, neural networks, finite automata, minimalization of automata, regular expressions, context-sensitive languages and linear bounded automata. Ambiguity in formal languages. PREREQUISITES: MA 2025 and MA 3026 or equivalent.

**CS 3750 Command, Control, and Communications Exercise Laboratory (C3 LAB) (2-4).**
A course to enable the student to participate actively in the design, implementation and analysis of experimental command and control exercises. It is a study of the application of automation to the function of command and control. Topics discussed and demonstrated include planning aids, decision support systems, operational decision aids, networking, situation displays and distributed intelligence. Laboratory exercises are designed to familiarize the student with computer display technology, distributed computing concepts, word processing, natural language access to data bases and varieties of automatic message handling systems. PREREQUISITES: CS 2105, CO 3111 and OS 3665 or consent of the Instructor.

**CS 3800 Directed Study in Computer Sciences (0-2 to 0-8).**
Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of the Instructor. Graded on Pass/Fail basis only.

**CS 3900 Selected Topics in Computer Science (3-0).**
Presentation of a wide selection of topics from current literature. Lectures on subjects of current interest and exploration may be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School. Tours of other facilities of interest may also be conducted. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

*Graduate Courses*

**CS 4112 Computer Systems (4-0).**
System design concepts in computer hardware-software combinations. Software engineering: specification, design, documentation and testing of complex computer programs. Resource allocation mechanisms, policies and problems. File system organization. Analysis, simulation and measurement techniques and their application to computer system design. Concepts are presented in terms of the fundamental insight provided by considering timesharing systems. PREREQUISITE: EE 2810, CS 3112.

**CS 4113 Compiler Design and Implementation (3-2).**
This course extends the concepts introduced in CS 3113. The methods and techniques of grammar analysis and parsing are developed with particular emphasis on LALR (1) based systems. The problems of dynamic versus static run time memory allocation; code generation; intermediate languages; error detection/analysis/correction at compile/run time; code optimization and multipass compilation are developed in additional detail. Laboratory periods will be used for analysis of existing compilers. PREREQUISITES: CS 3113 and CS 3300 or consent of the Instructor.

**CS 4200 System Analysis and Design (4-0).**
This course covers system development including the basics of analysis, design and testing; system description tools including decision tables, flowcharts, state diagrams and system

description techniques; system analysis tools; system analysis procedures; as well as important design issues such as hardware/software compatability, operating system compatability and information system requirements. PREREQUISITES: Completion of upper level CS series or consent of Instructor.

**CS 4202 Interactive Computation Systems (3-2).**
A study of the man-computer interface and methods for computer-assisted problem solving. System facilities for man-computer interaction. Computer graphics, transformations and graphics software. Data structures, memory requirements, storage, file, and data management. Languages for man-computer interaction including graphics, command, problem-oriented, and special purpose languages. Laboratory work includes individual projects using interactive graphical consoles. PREREQUISITES: EE 2810, CS 2110, or consent of Instructor.

**CS 4300 Data Base Systems (4-0).**
This course explores the technology of current Data Base Systems. The course deals with the historical development of Data Base Systems, current technology and future trends. The primary emphasis is the logical view of data base implementations, including the hierarchy, network and relational models and the language extensions required to support such systems. PREREQUISITES: CS 3112 and CS 3300, or CS 3030 and consent of Instructor.

**CS 4320 Data Base System Design (4-0).**
CS 4320 explores the design of Data Base Systems and current technology of Data Base software. Implementation techniques, viable alternatives, data base philosophies, data manipulation in complex information environments, and system requirements are explored. Examples of systems will be drawn from active DoD data base systems and current application/research in the private as well as public sectors. PREREQUISITE: CS 3020 or a knowledge of COBOL, or other higher level language, and consent of the Instructor.

**CS 4800 Directed Study in Advanced Computer Science (0-2 to 0-8).**
Directed advanced study in computer science on a subject of mutual interest to student and staff member. Intended primarily to permit students to pursue in depth subjects not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. A written report to the department chairman is required at the end of the quarter. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

**CS 4900 Advanced Topics in Computer Science (3-0).**
This course examines topics in the fields of current research in computer science. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

# DEPARTMENT OF ELECTRICAL ENGINEERING

*Satellite Communications Signal Analyzer control panel; part of a system designed and built by students.*

**Donald Evan Kirk**, Professor of Electrical Engineering; Chairman (1965)*; B.S., Worcester Polytechnic Institute, 1959; M.S., Naval Postgraduate School, 1961; Ph.D., Univ. of Illinois, 1965.

**Orestes Methodius Baycura**, Associate Professor of Electrical Engineering (1966); B.S.E.E., Carnegie Institute of Technology, 1957; M.S., Univ. of Pittsburgh, 1959; D.Sc. 1963.

**John Miller Bouldry**, Associate Professor of Electrical Engineering (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

**Stephen Breida**, Associate Professor of Electronics (1958); B.S.E.E., Drexel Institute of Technology, 1952; M.S.E.E., Purdue Univ., 1954.

**Robert Ward Burton**, Lieutenant Colonel, U.S. Air Force; Associate Professor of Electrical Engineering (1973); B.S., U.S. Naval Academy, 1955; S.M. (E.E.), Massachusetts Institute of Technology, 1960; E.E., 1960; Ph.D. Harvard Univ., 1964.

**Shu-Gar Chan**, Associate Professor of Electrical Engineering (1964); B.S., Univ. of Washington, 1954; M.S. Columbia Univ., 1954; Ph.D., Kansas Univ., 1964.

**Mitchell Lavette Cotton**, Associate Professor of Electronics (1953); B.S., California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E., Univ. of California at Berkeley, 1954.

**John Henry Duffin**, Professor of Electrical

Engineering (1962); B.S., Lehigh Univ., 1940; Ph.D., Univ. of California at Berkeley, 1959.

**Gerald Dean Ewing**, Associate Professor of Electrical Engineering (1963); B.S.E. E., Univ. of California at Berkeley, 1957; M.S.E.E., 1959; E.E., Oregon State Univ., 1962; Ph.D., 1964.

**Alex Gerba, Jr.** Associate Professor of Electrical Engineering (1959); B.E.E. Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

**Kenneth Gene Gray**, Assistant Professor of Electrical Engineering (1978); B.S.E. E., Univ. of Houston, 1970; M.S.E.E., 1971; Ph.D., Univ. of Illinois at Champaign-Urbana, 1974.

**David Boysen Hoisington**, Professor of Electronics (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

**Stephen Jauregui, Jr.**, Associate Professor of Electrical Engineering (1971), B.A., Univ. of California at Berkeley, 1956; M.S., Naval Postgraduate School, 1960; Ph.D., 1962.

**Jeffrey Bruce Knorr**, Associate Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

**George Heinemann Marmont**, Professor of Electronics (1959); B.S., California Institute of Technology, 1934; Ph.D., 1940.

**Glen Allen Myers**, Associate Professor of Electrical Engineering (1965); B.S.E.E., Univ. of North Dakota, 1955; M.S.E.E., Stanford Univ., 1956; Ph.D. 1965.

**John Everett Ohlson**, Professor of Electrical Engineering (1971); B.S. Massachusetts Institute of Technology, 1962; M.S.E.E., Stanford Univ., 1963; PhD., 1967.

**Rudolf Panholzer**, Professor of Electrical Engineering (1964); Dipl. Ing., Technische Hochschule in Graz, Austria, 1953; D. Sc., 1961; M.S.E.E., Stanford Univ., 1956.

**Sydney Richard Parker**, Professor of Electrical Engineering; (1966); B.E.E., City College of New York, 1944; M.S., Stevens Institute of Technology, 1948; Sc.D., 1964.

**John Patrick Powers**, Associate Professor of Electrical Engineering (1970); B.S.E.E., Tufts Univ., 1965; M.S., Stanford Univ., 1966; Ph.D., Univ. of California at Santa Barbara, 1970.

**George Anthony Rahe**, Professor of Electrical Engineering and Computer Science (1965); B.S., Univ. of Calfornia at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

**George Lawrence Sackman**, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E. 1959; Ph.D. Stanford Univ., 1964.

**Abraham Sheingold**, Distinguished Professor of Electronics (1946); B.S., College of the City of New York, 1936; M.S., 1937.

**Donald Alan Stentz**, Associate Professor of Electronics (1949); B.S., Duke Univ., 1949; M.S. Naval Postgraduate School, 1958.

**Robert Denney Strum**, Associate Professor of Electrical Engineering (1958); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

**Tien-Fan Tao**, Professor of Electrical Engineering (1971); B.S., National Taiwan Univ., 1955; M.S., Univ. of Pennsylvania, 1958; Ph.D., Harvard Univ., 1963.

**George Julius Thaler**, Distinguished Professor of Electrical Engineering (1951); B.E., John Hopkins Univ., 1940; D. Eng. 1947.

**Harold Arthur Titus**, Professor of Elec-

tronics (1962); B.S., Kansas Univ., 1952; M.S. Stanford Univ., 1957; Ph.D., 1962.

**John Thomas Vinson**, Commander, U.S. Navy; Instructor in Electrical Engineering (1976); B.S. Naval Postgraduate School, 1967, M.S. 1972.

**John Robert Ward**, Professor of Electrical Engineering (1962); B.Sc., Univ. of Syndey, 1949; B.E., 1952; Ph.D., 1958.

**Milton Ludell Wilcox**, Associate Professor of Electrical Engineering (1958); B.S., Michigan State Univ., 1938; M.S., Univ. of Notre Dame, 1956.

**John McReynolds Wozencraft**, Professor of Electrical Engineering (1977); B.S., U.S. Military Academy, 1946; M.S., Massachusetts Institute of Technology, 1951; E.E., 1951; Ph.D. 1957.

**Rovert Donald Yingling**, Major, U.S. Air Force; Instructor in Electrical Engineering (1977); B.S.E.E., Oklahoma State Univ., 1967; M.S.E.E., Massachusetts Institute of Technology. 1968.

### EMERITUS FACULTY

**William Malcolm Bauer**, Professor Emeritus (1946); B.S., Northwestern Univ., 1927; E.E., 1928; M.S. Harvard Univ., 1929; D.Sc., 1940.

**Jesse Gerald Chaney**, Professor Emeritus (1944); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

**Paul Eugene Cooper**, Professor Emeritus (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

**Edward Markham Gardner**, Professor Emeritus (1948); B.S., Univ. of London, 1923; M.S., California Institute of Technology, 1938.

**George Robert Giet**, Distinguished Professor Emeritus (1925); A.B., Columbia Univ., 1921; E.E., 1923.

**Raymond Kenneth Houston**, Professor Emeritus (1946); B.S., Worcester Polytechnic Institute, 1938; M.S., 1939.

**Clarence Frederick Klamm, Jr.** Professor Emeritus (1951); B.S., Washington Univ. 1943; M.S., 1948.

**Robert Lee Miller**, Professor Emeritus (1946); B.Ed., Illinois State Normal Univ., 1936; M.S., Univ. of Illinois, 1941.

**Raymond Patrick Murray**, Associate Professor Emeritus (1947); B.S., Kansas State College, 1937; M.S., Brown Univ. 1953.

**Herbert LeRoy Myers**, Assistant Professor Emeritus (1951); B.S., Univ. of Southern California, 1951.

**Charles Benjamin Oler**, Professor Emeritus (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D.Eng., John Hopkins Univ., 1950.

**Charles Harry Rothauge**, Professor Emeritus (1949); B.E., John Hopkins Univ., 1940: D.Eng., 1949.

**William Conley Smith**, Professor Emeritus (1946); B.S., Ohio Univ., 1935; M.S., 1939.

**John Benjamin Turner, Jr.**, Associate Professor Emeritus (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California at Berkeley, 1948.

**Allen Edgar Vivell**, Dean Emeritus (1945); B.E., John Hopkins Univ., 1927; D. Eng. 1937.

**Richard Carvel Hensen Wheeler**, Professor Emeritus (1929); B.E., John Hopkins Univ., 1923; D. Eng., Rensselaer Polytecnic Institute, 1926.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

### DEPARTMENTAL REQUIREMENTS FOR DEGREES IN ELECTRICAL ENGINEERING

In addition to meeting the minimum specific

academic requirement for these degrees as given below, candidates must also satisfy the general degree requirements as determined by the Academic Council.

### MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

1. A minimum of 40 quarter hours of graduate work beyond the requirements for the Bachelor of Science in Electrical Engineering degree shall be required for the degree of Master of Science in Electrical Engineering. The academic records of those students who do not complete the requirements for the Bachelor of Science in Electrical Engineering degree at the Naval Postgraduate School will be evaluated by the Department of Electrical Engineering to determine what additional undergraduate courses need to be taken to qualify for entry into the graduate program. Of the 40 quarter hours a minimum of four courses, of at least 12 hours must be in the course sequence 4000-4999. At least 30 hours shall be required in Electrical Engineering subjects. An acceptable thesis must be presented. Approval of all programs must be obtained from the Chairman, Department of Electrical Engineering.

2. An acceptable thesis for the Engineer's degree may be accepted as meeting the thesis requirements of the Master's Degree. However, the thesis requirement for the Master's Degree may be waived upon the approval of the Chairman of the Department under the following circumstances:

a. The student has been admitted to the Engineer's Degree, Doctor of Engineering or Doctor of Philosophy Degree program.

b. The student has completed four (4) 4000 level courses of a minimum of twelve (12) credits over and above the course requirements for the Master's Degree.

### MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in electrical engineering at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Electrical Engineering Department. A total minimum of 12 quarter hours at the 4000 level and an acceptable thesis are required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

### ELECTRICAL ENGINEER

1. Students with acceptable academic backgrounds may enter a program leading to the degree Electrical Engineer. Normally this program is of three years' duration.

2. A minimum of 80 graduate course credits are required for the award of the Engineer's degree. Of these at least 30 hours are to be in courses in the sequence 4000-4999. An acceptable thesis must be completed. A departmental advisor will be appointed for consultation in the development of a program of study. Approval of all programs must be obtained from the Chairman Department of Electrical Engineering.

### DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Electrical Engineering has an active program leading to the degrees of Doctor of Philosophy and Doctor of Engineering. Areas of special strength in the department are signal processing, communications systems, electronic systems and devices and control theory. Joint programs with other departments are possible. A noteworthy feature of the program leading to the Doctor of Engineering degree is that the student's research is conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the Federal Government. The degree requirements are as outlined under the general school requirements for the Doctor's degree.

## ELECTRICAL ENGINEERING LABORATORY

The Electrical Engineering Department Laboratories have excellent facilities in almost all phases of modern electrical engineering. At present, the laboratories are divided into Communications and Navigation, Microwaves and Antennas, Radar and Electronic Countermeasures, Signal Processing, Microprocessors, General Measurements, Solid State Devices, Lasers, Control Systems, Sonar and Energy Conversion Laboratories. There are extensive service facilities including a calibration laboratory where a continuous program of calibration and maintenance of laboratory instruments is carried out.

In addition to the usual experimental and instructional type laboratories, status as a Naval facility enables the Department to utilize a number of modern systems as adjuncts to the laboratory. These include communications, radar, telemetry, sonar, countermeasures and navigational systems.

Students in the Department have access to the Computer Center (IBM/360 System) as well as the Computer Laboratory which is a school-wide direct access computer complex where each student may program and operate the computer system for the solution of his own problem. The facility includes a medium size digital computer, two high performance input-output display units, and a general purpose hybrid/analog computer; all integrated into a single system. These facilities support a wide range of research and instruction in digital and hybrid computation and simulation.

As a part of the laboratory facility, there are generous research spaces available for thesis students to conduct their research problems on an individual basis.

## DEFENSE COMMUNICATIONS COURSES

*Upper Division or Graduate Courses*

**CO 3111 C3 Mission and Organization (4-0).**
Organization of the Department of Defense emphasizing command, control and communications organization. A study of service communication organizations including interoperability is made. DCS, CSCS, WWMCCS, Nuclear Release Systems, NATO, and Intelligence Reporting Systems organization and network concepts are studied. Command and control facilities, ADP support and executive aids are discussed. PREREQUISITES: U. S. Citizenship and SECRET clearance.

**CO 3112 Navy Telecommunications Systems Definition and Management (4-0).**
Review of Navy Telecommunications Systems (ship and shore) followed by analysis of technical and managerial problems associated with current and programmed systems. Navy Systems interface with Defense Communications System is discussed. Course entails field trips to telephone, satellite and Naval Communication Stations and message centers. PREREQUISITES: U.S. Citizenship and SECRET clearance.

*Graduate Course*

**CO 4113 Policies and Problems in C3 (4-0).**
An in-depth study of the operational capabilities and limitations of selected Command, Control and Communications Systems and an analysis of the impact of organizational behavior on C3 systems design and performance. Additionally, the course will provide insight into the complexities imposed on C3 systems as the force structure becomes more heterogeneous, as in the case of NATO. PREREQUISITES: Enrollment in the Command, Control and Communications curriculum, CO 3111, NS 3064.

## COURSES FOR ENGINEERING AND SCIENCE CURRICULA

**EE 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

**EE 0951 Seminar (0-1).**
Lectures on subjects of current interest will be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School.

**EE 0960 Thesis Topics Seminar (0-1).**
Introductory presentations by NPS faculty members of current research projects.

Intended to inform first-year students of potential thesis areas.

*Upper Division Courses*

**EE 2101 Basic Circuit Theory (3-2).**
An introductory course designed for the Electronics and Communications Engineering curricula. This course is intended for students with no previous background in electrical engineering. The fundamental concepts of voltage, current, power, energy, signals, sources and Kirchhoff's laws are presented and applied to resistive circuits. Capacitance, inductance and operational amplifiers are introduced. Simple networks containing these elements are then analyzed for step and sinusoidal inputs. Complex numbers with applications to basic sinusoidal analysis. PREREQUISITES: Calculus (may be concurrent).

**EE 2102 Circuit Analysis (4-2).**
Topics include: a review of Kirchhoff's laws and other concepts central to circuit analysis; node, loop and state equations for circuits; Laplace transform analysis leading to network and transfer functions and poles and zeros; sinusoidal steady-state analysis including AC power, frequency response, resonance and plots for sinusoidal network functions. PREREQUISITES: EE 2101, or a previous course in circuits.

**EE 2103 Linear Systems Analysis (4-2).**
Formulation of system models including state equations, transfer functions and system diagrams; computer and analytical solution of system equations; frequency analysis using Fourier transform and series; convolution in both the time and frequency domains. PREREQUISITES: EE 2102, differential equations and FORTRAN.

**EE 2104 Electrical Engineering Fundamentals (4-2).**
An introductory course designed for the Naval Engineering curriculum. Circuit elements, signals and waveforms; power and energy; Kirchhoff's laws and resistive networks; diode circuit applications; Laplace transform; step and sinusoidal response of dynamic networks; polyphase circuits. PREREQUISITE: Calculus.

**EE 2111 Engineering Fundamentals for Aeronautical Engineers (4-2).**
An intensive course covering the fundamentals of Electrical Engineering including both circuits and electronic devices for students in Aeronautical Engineering. PREREQUISITES: Differential equations and Laplace transform.

**EE 2114 Communications Theory (4-1).**
In this first course on the electrical transmission of signals, the following concepts are formulated mathematically and then considered in terms of devices and systems: sampling, pulse coding; amplitude, phase, and frequency modulation; time and frequency multiplexing. Basic radio ranging and communications systems are developed and link calculations are made. PREREQUISITES: EE 2103 and EE 2212 or equivalent.

**EE 2121 Circuit Fundamentals (4-2).**
An introductory course designed for the Avionics curriculum. Circuit concept and circuit elements; power and energy; basic circuit laws; steady-state solutions; Laplace transform. Parts of the course may be taught in a self-study mode. PREREQUISITE: Calculus.

**EE 2122 Linear System Fundamentals (4-2).**
A continuation of EE 2121 for Avionic engineers. Topics include state equations and system diagrams; computer and analytical solution of system equations; Fourier transform methods and frequency response; convolution. PREREQUISITES: EE 2121, differential equations and FORTRAN.

**EE 2150 Circuits and Systems (5-2).**
An advanced review of circuits and systems intended for students who have previous education in these areas. The course is conducted primarily in a self-study mode and includes the subject matter of EE2101, 2102, and 2103. *Graded on Pass/Fail basis only.* PREREQUISITE: Sufficient background in circuits and systems. (May be taken through Continuing Education as the mini-course sequence EE 2151-56)*

**EE 2211 Electronics Fundamentals (4-2).**
An introduction to electronic devices and circuits. Electrical properties and charge-flow mechanisms of crystalline semiconductor materials; properties of p-n junctions in diodes

and bipolar transistors; static models for these devices; characteristics and fabrication of integrated circuits; applications of diodes, transistors, and integrated circuits, especially in digital systems; the field effect transistor. PREREQUISITE: A first course in electrical engineering.

**EE 2212 Electronics Engineering Fundamentals (4-3).**
Characteristics of discrete device amplifiers and operational amplifiers (OP-AMPS). Analysis and design of amplifiers including frequency response and biasing considerations. Applications of feedback amplifiers and OP-AMPS. PREREQUISITE: EE 2211.

**The minicourses are described in the Continuing Education catalog.*

**EE 2213 Advanced Review of Electronics Engineering Fundamentals (4-3).**
An advanced review of semiconductor devices and circuits intended for students who have previously studied the subject matter of EE 2211 and EE 2212. *Graded on Pass/Fail basis only.* PREREQUISITE: Sufficient background in electronic circuits.

**EE 2216 Pulse and Digital Circuits (3-3).**
The topics studied include basic logic circuits, waveform generators, trigger and timing circuits, multivibrators, A/D and D/A converters, applications of OP-AMPS. PREREQUISITES: EE 2212 or equivalent.

**EE 2217 Communication Circuits (3-2).**
Electronic circuits used for the transmission and reception of analog and digital signals. Topics include oscillators, modulators, demodulators, frequency synthesizers and converters, and special-purpose amplifiers. PREREQUISITE: EE 2114.

**EE 2411 Control Systems (3-3).**
The application of feedback principles to the design of linear control systems using frequency domain (Bode-Nichols), s-domain (Root Locus) and state variable methods. Performance criteria including steady-state accuracy, transient response specifications, bandwidth and integral performance indices are presented. Laboratory work includes testing and evaluation of physical systems and simulation studies. PREREQUISITES: EE 2103 and FORTRAN or equivalent.

**EE 2621 Introduction to Fields and Waves (4-0).**
Static field theory is developed and applied to boundary value problems. Time-varying Maxwell equations are developed and solutions to the wave equations are presented. Additional topics include skin effect, reflection of waves and radiation. PREREQUISITE: Calculus.

**EE 2622 Electromagnetic Engineering (3-1).**
A continuation of EE 2621. Topics include transmission lines, waveguides and cavity resonators. Applications are presented in the laboratory. PREREQUISITE: EE 2621 or equivalent.

**EE 2623 Electromagnetic Theory Review (4-1).**
A comprehensive review of basic electromagnetic theory intended for students who have previously studied the subject matter of EE 2621 and EE 2622.*Graded on Pass/Fail basis only.* PREREQUISITE: Sufficient background in electromagnetic theory.

**EE 2810 Digital Machines (3-3).**
Basic principles of digital system design with emphasis upon the organization and programming of simple computers and microprocessors. Elements of Boolean algebra and logic design. Storage organization and control. Input-output data flow. Relations of machine logic to program design. Laboratory sessions are devoted to study of digital logic elements, processing, storage and I/O units. PREREQUISITE: None.

*Upper Division or Graduate Courses*

**EE 3111 Avionic Systems (4-2).**
A course for aeronautical engineering students. Topics include: radar principles, avionic computers, laser and infrared devices, sonar, navigation systems, systems engineering considerations. PREREQUISITE: EE 2111.

**EE 3215 Microwave Devices (4-2).**
Topics include the physics and characteristics of klystrons, magnetrons, traveling wave tubes, avalanche diodes, transferred electron diodes, Schottky barrier diodes, microwave transistors, varactor diodes, ferrites and PIN diodes. System applications such as amplification, oscillation, detection, mixing, multipli-

cation, tuning, filtering, phase shifting, circulating, isolating, switching and attenuating are also discussed. PREREQUISITES: EE 2212, EE 2622 (or equivalent) or permission of Instructor.

**EE 3263 Integrated Circuit Electronics (3-3).**
MSI, LSI, and VLSI technologies for Bipolar and MOS devices; digital IC's including memories, arithmetic devices, microprocessors and signal processing devices; analog and sampled analog integrated circuits such as sample-and-hold circuits, charge transfer devices and signal processing devices; surface acoustic wave and reflective array compressor devices and their applications. Current developments in integrated circuits are presented. PREREQUISITES: EE 2216 and EE 2810 or their equivalent.

**EE 3311 Modern Energy Conversion (3-2).**
Application of physical principles to the conversion of energy to the electric form. The devices studied are thermoelectric, thermionic, electrochemical, solar and others as time permits. PREREQUISITES: Introductory heat power, chemistry and solid state topics or consent of Instructor.

**EE 3312 Electromagnetic Machines (3-3).**
Introduction to power circuits, transformers, control motors, single and three phase motors, and DC and AC generators. Physical principles and basic analysis techniques are stressed. PREREQUISITES: EE 2102 and EE 2621 or equivalent.

**EE 3413 Fundamentals of Automatic Control (3-3).**
Formulation of system models including state equations, transfer functions and system diagrams. Starting with a performance measure, design methods are studied for both transfer function and state equation models. Computer simulation is utilized and physical systems are tested and evaluated. PREREQUISITES: EE 2104 and FORTRAN.

**EE 3420 Engineering Fundamentals of Electro-optics (3-1).**
An introduction to elements of electro-optic systems. Elements such as lasers, light emitting diodes, and detectors are studied to characterize their operating parameters and limitations. The influence of other elements such as lens systems and properties of the propagation channel are also studied. PREREQUISITES: EE 2212 or equivalent.

**EE 3431 Principles of Radar Systems (4-2).**
A course for students in the Avionics and Weapons curricula. Topics include microwave, devices, microwave propagation, antenna fundamentals, electronically steerable arrays, pulse radar basics, detection of signals in noise, the radar equation, CW, pulse doppler, moving-target indicators, pulse compression, the ambiguity function, and tracking radars, conical scan, track-while-scan, scan with compensation and monopulse. PREREQUISITE: Consent of Instructor.

**EE 3472 Principles of Navigation, Missile and Avionics Systems (3-2).**
The principles of operation of navigation, missile and avionics systems are presented. Topics are selected from the following areas to address the specific interests of the class: IR, EO, radar, laser and acoustic sensors; inertial platforms; gyros and accelerometers; Loran, Omega, GPS, guidance, fire control and tracking systems. PREREQUISITE: EE 2411 or equivalent.

**EE 3473 Navigation, Missile and Avionics Systems (3-2).**
This course covers essentially the same material as EE 3472, but with the addition of detailed analysis of specific systems. PREREQUISITES: EE 2411, U.S. Citizenship and SECRET clearance.

**EE 3571 Stochastic Analysis of Signals (4-1).**
Fundamental concepts necessary for handling non-deterministic signals and noise in communication, control and signal processing systems. Topics include properties of random variables, statistical averages, autocorrelation and power spectral density, transform relations, stationarity and ergodicity, noise models. The laboratory exercises illustrate the concepts and principles using real signals. PREREQUISITES: EE 2114 and a basic course in probability.

**EE 3631 Electromagnetic Radiation and Compatibility (3-2).**
This course covers wire and aperture

antenna elements and arrays for communication and radar systems. Basic compatibility fundamentals are also discussed. While essentially stressing engineering, this course applies field theory concepts developed in earlier courses to military systems. PREREQUISITE: EE 2622 or equivalent.

**EE 3652 Microwave Circuits and Measurements (3-2).**
A continuation of EE 2622, this course further develops the distributed circuit concepts necessary for the understanding of microwave integrated circuits and subsystems. Waveguides, cavities, planer lines, perturbation theory and discontinuities are discussed. Network characterization with scattering parameters is presented and followed by a discussion of selected networks such as couplers, impedance transformers and filters as building blocks for microwave integrated circuits. Topics from the current literature are covered according to class interest. The laboratory focuses on measurement techniques peculiar to microwave frequencies. PREREQUISITE: EE 2622 or equivalent.

**EE 3671 Propagation (3-0).**
Properties of the earth and its atmosphere and their effect on radiowave propagation from ELF through millimeter wave-lengths. Topics include noise, scatter, propagation anomalies, and frequency selection. PREREQUISITE: EE 2622 or equivalent.

**EE 3812 Switching Circuit Theory and Design of Digital Systems (3-2).**
Synthesis of combinational and sequential networks. Design of digital systems using (1) the classical approach (state diagrams, etc.), (2) MSI functional building blocks, and (3) microprocessors. Laboratory work is oriented around individual projects in logic system design. PREREQUISITE: EE 2810 or equivalent.

**EE 3822 Engineering Applications of Computers (3-3).**
Use of digital, analog, and hybrid computing machines in various application areas, e.g., systems design, parameter optimization, adaptive control, data acquisition and filtering, signal processing, biomedical instrumentation. Special techniques for real-time processing and simulation. Laboratory work is conducted in small groups and involves application studies using the various types of computers. PREREQUISITE: EE 2810.

*Graduate Courses*

**EE 4121 Advanced Network Theory (3-2).**
Circuit elements and multiport networks. Tests and criteria for realizability. Driving point and transfer function synthesis with passive and active components. The approximation problem and circuit synthesis to meet design criteria. Topics include design with inductorless filters, gyrators, operational amplifiers and integrated circuit components. PREREQUISITES: EE 2103 and EE 2211 or equivalent.

**EE 4410 Mathematical Models and Simulation for Control Systems (3-2).**
Modeling concepts and techniques for linear and nonlinear systems. Philosophy of model studies. Verfication of the model and its parameters. Design studies using computer models. PREREQUISITE: EE 2411.

**EE 4411 Digital Control Systems (3-2).**
Discrete systems are described and analyzed using time-domain and z-transform methods. Analytical design techniques are studied, as well as the engineering characteristics of computer control systems. Laboratory work includes simulation studies as well as digital control of an analog system. PREREQUISITE: EE 2411.

**EE 4412 Nonlinear Systems (3-2).**
Analysis and design of nonlinear systems with phase plane and describing function methods. Accuracy, limit cycles, jump resonances, relay servos and discontinuous systems are considered. Digital simulation is used extensively. PREREQUISITE: EE 2411.

**EE 4413 Linear Optimal Estimation and Control (3-2).**
Performance measures; dynamic programming, the linear regulator problem; state estimation using observers and Kalman filters; Monte Carlo simulation; combined estimation and control. PREREQUISITES: EE 2411 and EE 3571 or equivalent.

EE 4415 Design of Linear Control Systems (4-0).
This course treats advanced concepts in the design of linear systems. Frequency response and root locus methods are applied to the design of stabilization and improvement of performance, using both graphical and analytical (algebraic) methods. For more complex systems, the Mitrovic-Siljak relationships are developed, leading to coefficient plane, parameter plane and parameter space methods. PREREQUISITE: EE 2411.

EE 4416 Advanced Topics in Modern Control Theory (3-2).
A course intended to acquaint the students with advanced topics and current developments in control theory and applications. Topics are selected by the instructor and may include such subjects as: the calculus of variations and Pontryagin's minimum principle applied to optimal control problems; numerical solution of two-point boundary-value problems; nonlinear estimation techniques; large-scale systems; system identification; case studies of fire control and ship control systems. PREREQUISITE: Consent of the Instructor.

EE 4418 Ship Control Systems (3-2).
Theory of motion of ships. Basic ship control systems; steering control, roll stabilization, boiler control loops, speed and propulsion controls. Sea states and their effects. Performance objectives and performance specifications. Models. Simulation studies. PREREQUISITE: EE 2411.

EE 4422 Electro-optic Systems Engineering (3-1).
Advanced topics and applications of electro-optics. Infrared sources, detectors, applications. Atmospheric effects, high energy lasers, fiber optics and other current topics of interest. PREREQUISITE: EE 3420.

EE 4432 Radar Systems (3-2).
The principles of pulse radar systems are developed in classroom and laboratory exercises. Additional topics developed include the radar equation, doppler systems, MTI automatic-target-tracking systems, pulse compression, and multiple-unit steerable-array radars. PREREQUISITES: EE 3571 and EE 3215 (may be concurrent), or equivalent. This course is intended for students who do not have U.S. Citizenship.

EE 4433 Advanced Radar Systems (3-2).
The radar range equation is developed in a form including signal integration, the effects of target cross-section, fluctuations, and propagation losses. Modern techniques discussed include pulse compression, frequency- modulated radar, MTI, pulse doppler systems, monopulse tracking systems, multiple-unit steerable array radars, and synthetic aperture systems. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with pulse compression, and with the measurements of radar cross section of targets. PREREQUISITES: EE 3571 and EE 3215 (may be concurrent), or equivalent, SECRET clearance and U.S. Citizenship.

EE 4451 Sonar Systems Engineering (4-2).
A study of the theory and engineering practices pertaining to passive and active sonar systems. Current fleet systems and developmental projects are analyzed. The objective of the course is to determine how the engineering design is conditioned by the characteristics of the transmission medium as well as the operational requirements. PREREQUISITES: PH 3452, EE 4572 or EE 4716, U.S. Citizenship and SECRET clearance.

EE 4452 Underwater Acoustic Systems Engineering (4-2).
A study of the theory and engineering principles of underwater acoustics, communications, surveillance, and echo ranging systems. Emphasis is placed on the principles and problems common to all underwater acoustic systems, and the design tradeoffs that are available to the engineer. The laboratory periods are used for making engineering tests on existing systems and testing a subsystem of the student's own design. PREREQUISITE: EE 3571.

EE 4461 Advanced Systems Engineering (3-1).
An introduction to the engineering of large scale systems. The primary aim of this course is to increase the student's awareness of the complex interactions of various disciplines and the main recurring problems in systems engineering. The class will be expected to participate in a group project involving a feasibility

study of a proposed new system. PREREQUISITES: EE 3571, EE 2411.

EE 4481 Electronic Warfare Techniques and Systems (3-3).
Active and passive countermeasure techniques are considered including signal representation, signal analysis, and signal interception. Important parameters of radar and communications systems are defined. Denial and deceptive jamming techniques are considered along with countermeasure and counter-countermeasure techniques. Signal intercept systems are treated. Acoustic, radio-frequency, infrared, and optical countermeasures are discussed. PREREQUISITES: EE 4433, U.S. Citizenship and SECRET clearance.

EE 4482 Signals Intelligence (SIGINT) Systems Engineering (2-2).
This course covers airborne, shipboard, and ground based intercept and direction finding system techniques used against simple and sophisticated electromagnetic radiation systems. Among the topics covered are current state of the art for wideband and directional antennas, wideband RF preamplifiers, scanning and chirping receivers, displays, recorders, pattern recognizers and signal analysis devices. The laboratory periods are largely devoted to the specification and block diagram of systems to handle specified SIGINT tasks. PREREQUISITES: EE 4481 or permission of Instructor. U.S. Citizenship and SECRET clearance are required.

EE 4483 Principles of Electronic Warfare (unclassified) (3-2).
This course in electronic warfare is intended for students who do not have U. S. Citizenship. Particular attention is paid to the problems encountered in jamming radar systems, to the intelligence information needed for jamming, and to anti-jamming features for radars. Other topics include intercept receivers, intercept probability, direction finding, confusion reflectors, and infrared techniques. In the laboratory, basic principles are applied to jamming radar systems. PREREQUISITES: EE 4432 or EE 4433.

EE 4550 Digital Communications (4-0).
Digital communications is becoming increasingly important in military systems. This course discusses some of the advantages and limitations of digital communications systems, to include: packet switching, cryptographic protection, vocoders, pulse code modulation, frame and bit synchronization, telephone line modems, intersymbol interference and adaptive equalizers, wide-band modems, exchange of band-width and signal-to-noise ratio, threshold effects with non-linear modulators, diversity combining, and error detection and correction techniques. PREREQUISITE: EE 3571.

EE 4560 Communications ECCM (3-2)
Methods of reducing the effects of jamming on radio communications systems are considered. Matched filter and correlator theory and application to spread spectrum techniques of digital data transmission are treated. Synchronization problems and techniques are presented. Codes for error correction are briefly considered. Frequency hopping, time hopping and hybrid systems are studied in addition to direct sequence spreading. Use of steerable null antennas is described. PREREQUISITE: EE 3571.

EE 4572 Statistical Communication Theory (3-2).
Advanced statistical methods applied to the analysis of signals and noise in communications systems, including applications to radar and sonar. Topics include the responses of linear and non-linear systems, error measures, optimal filters, decision schemes and parameter estimation, broadband concepts and applications to analog and digital communications. The laboratory provides the student with the opportunity to do independent analytical studies, experimental work, or computer simulation related to the properties of signals and noise. PREREQUISITE: EE 3571.

EE 4581 Information Theory (3-2).
Concepts of information measure for discrete and continuous signals. Fundamental theorems relating to coding and channel capacity. Effects of noise on information transmission. Coding methods for error control in digital communication systems. Selected applications of the theory to systems. PREREQUISITE: EE 3571.

**EE 4591 Communication Satellite Systems Engineering (3-2).**
This course covers communication satellite systems including the satellite and user terminals. Subjects include orbits, power sources, antennas, stabilization, link calculations, multiple access techniques, modulation and demodulation schemes, phase-locked loops, coding, transponder intermodulation and hardlimiting, receiver design, spread spectrum in SATCOM for multiple access, anti-jam and covert communications. PREREQUISITE: EE 3571.

**EE 4623 Advanced Electromagnetic Theory (3-0).**
This course provides an introduction to mathematical techniques of importance in the solution of electromagnetic problems by numerical methods. Applications of Navy interest in the areas of antenna and microwave theory are covered. These include radiation and scattering from wires and surfaces and wave propagation on structures used in microwave integrated circuitry. PREREQUISITES: EE 3631, or EE 3652 or equivalent, or consent of Instructor.

**EE 4823 Advanced Digital Computer Systems (3-1).**
A course intended to acquaint the student with recent developments in digital systems as found in the research publications. Topics are selected at the discretion of the instructor and may include such subjects as: machine organization, computer graphics, manmachine interfaces, design automation, parallel processing, microcomputers and microprocessors. An individually planned laboratory program is directed toward an experimental project involving state-of-the-art utilization of computer hardware or software. PREREQUISITE: EE 3812.

**EE 4845 Principles of Digital Filters (3-2).**
A course in the techniques and algorithms involved in the processing of discrete signals using the principles of digital filtering. Included is the approximation problem of converting frequency and time domain specifications into recursive and non-recursive filter algorithms, filter synthesis and realization, the discrete Fourier and other transformations, extension to multidimensional signal analysis, and image processing. Other topics included are error analysis, noise generation due to finite precision arithmetic, and limit cycles. Problems and exercises are derived from military applications and include filter design, realization, and testing. PREREQUISITE: EE 2114 or equivalent.

**EE 4875 Advanced Digital Methods (4-2).**
The intent of this course is to present the use of advanced digital methods ("state-of-the-art"). An essential part of the course will be the student's laboratory experience with advanced hardware configured into subsystems and systems. Topics will include microcomputers, microprogramming (including devising and making programmed read-only-memories, PROM's), digital encoding, and decoding methods including interfacing and transmission, digital filters, display methods and applications of new logic families (CCD, ECL, $I^2L$), and of various kinds of memory devices. PREREQUISITE: EE 3571.

**EE 4900 Special Topics in Electrical Engineering (2-0 to 5-0).**
Supervised study in selected areas of electrical engineering to meet the needs of the individual student. A written report is required at the end of the quarter. *Graded on a Pass/Fail basis only.* PREREQUISITE: Consent of the Department Chairman.

## COURSES FOR INTERDISCIPLINARY CURRICULA

**EE 2107 Introduction to Electrical Engineering (4-2).**
The first in a sequence of courses designed for the Weapons Systems Engineering curricula. Electrical quantities and circuit elements; power and energy; Kirchhoff's laws and simple circuits; Laplace transform; step and sinuisoidal response of simple circuits; electronic building blocks including diode and operational amplifier applications. PREREQUISITE: Calculus.

**EE 2108 Linear Systems Analysis (4-2).**
The second in a sequence of courses designed for the Weapons Systems Engineering curricula. Formulation of system models including state equations, transfer functions and system diagrams; computer and analytical solution of

system equations; frequency response analysis including Fourier transform and series and convolution. PREREQUISITES: EE 2107, differential equations and FORTRAN.

EE 2225 Pulse and Digital Circuits (2-1).
A course to prepare the student to understand pulse systems in radar and electromagnetic warfare. Included are wave-shaping and timing circuits, as well as basic logic circuits and concepts. Devices and circuits discussed include linear and non-linear wave shaping circuits using diodes and op-amps, gates, flip-flops, registers, counters, displays, decoders, multiplexers, A/D and D/A converters, sample-and-hold, and pulse stretchers. Laboratory experiments reinforce and extend concepts presented in the lectures. PREREQUISITE: EE 2721.

EE 2418 Control Systems (2-1).
This course develops the basic tools of the control systems engineer. The applications to electronic warfare are emphasized in the examples and laboratory experiments. The dynamics for a radar control system, a missile seeker head tracking system and missiles are investigated. Basic topics are introduced such as signal flow graphs and system step and frequency response characteristics, and digital systems theory as used in radar tracking and command guided and semiactive homing missiles. PREREQUISITES: MA 3139, SECRET clearance and U.S. Citizenship.

EE 2422 Communications Systems (3-2).
Analog communications systems with identification of subsystems; power conversion, oscillators, modulation and demodulation, special purpose circuits, elementary communication theory. PREREQUISITE: EE 2721.

EE 2424 Signal Transmission Systems (4-1).
This course covers the elements of electrical energy transmission as applied to communications. The principles of electromagnetic waves are represented, guided waves on transmission lines and waveguides are studied. The radiated field in space, antennas and propagation are covered, and a representative system, such as a satellite communications system is studied. PREREQUISITE: EE 2810 (may be concurrent).

EE 2624 Electromagnetic Theory (4-1).
This course covers the experimental laws of electromagnetic theory and the development of Maxwell's equations. Maxwell's equations are then utilized in the study of plane waves, transmission lines, wave guides, cavity resonators and elementary radiation. Laboratory experiments dealing with high frequency components and measurements reinforce and extend the concepts presented in the lectures. PREREQUISITES: MA 2181 and EE 2721 or equivalent.

EE 2721 Introduction to Electronic Systems (4-1).
A first course in electronic systems for the ASW, EW, C3, and Tele-communications Systems curricula. Emphasis is on the functional aspects of basic circuits and signals. Topics include electrical quantities, resistive circuits, inductance and capacitance, operational amplifiers, time and frequency response, diodes and logic elements. PREREQUISITE: Mathematics through calculus.

*Upper Division or Graduate Courses*

EE 3118 Communications Systems (4-2).
The fourth in a sequence of courses designed for the Weapon Systems Engineering curricula. Modulation systems, analog and digital types; complete modulation systems incorporating pulse and pulse code schemes; noise in communication systems; error detection and correction. PREREQUISITES: EE 2108, MA 3139 or equivalent.

EE 3410 Continuous and Digital Control Systems (4-2).
The third in a sequence of courses designed for the Weapon Systems Engineering curricula. Feedback; performance measures; root locus methods; systems with digital controllers; the matrix approach to analysis and design. PREREQUISITES: EE 2108, MA 3139 or equivalent.

EE 3425 Communication Systems Analysis (3-3).
The final course in the Communications Management sequence. The objective is to look at the overall Communications System with particular attention to system aspects. Some of the subjects considered are: underlying communication theory, multiplexing methods,

evaluation and selection of systems, modern trends in systems. PREREQUISITE: EE 2424.

**EE 3625 Electromagnetic Radiation, Scattering and Propagation (4-2).**
This course covers the fundamentals of antennas used in the VLF through the microwave portion of the electromagnetic spectrum. Scattering and propagation in this part of the spectrum is also discussed, as are those elements of electromagnetic compatibility which relate to radiation. Laboratory exercises relating to pattern and impedance measurement, and use of computer programs further enhance the student's understanding of those concepts presented in the lectures. PREREQUISITE: EE 2624.

**EE 3714 Introduction to Signals and Noise (4-1).**
A course in the analysis of signals and noise for the ASW, EW and C3 curricula. Topics include Fourier analysis of periodic and pulse signals, linear filter response, correlation and spectral density of random signals, matched filters and sampling. PREREQUISITES: EE 2721 and a first course in probability.

*Graduate Courses*

**EE 4423 Electro-Optic Systems and Countermeasures (3-1).**
A study of military applications of electro-optic systems, IR and EO missile seekers, laser designators, optical surveillance, high energy laser systems, laser communications and laser radar. Emphasis is on system applications, countermeasures and counter-countermeasures. PREREQUISITES: PH 3271 or EE 4422 and SECRET clearance and U.S. Citizenship.

**EE 4434 Microwave Devices and Radar (4-2).**
Those microwave devices most important in radar and in electronic warfare systems are studied, including magnetrons, traveling-wave tubes, and solid-state diodes. The radar range equation is developed. In addition to basic pulse radar, modern techniques are discussed including doppler systems, tracking radar, pulse compression, and electronically steerable array radars. Electromagnetic compatibility problems involving radar systems are considered. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with performance measurement methods, automatic tracking systems, pulse compression, and the measurement of radar cross section of targets. PREREQUISITES: EE 4716, EE 3625 (may be taken concurrently) or consent of Instructor; SECRET clearance and U.S. Citizenship.

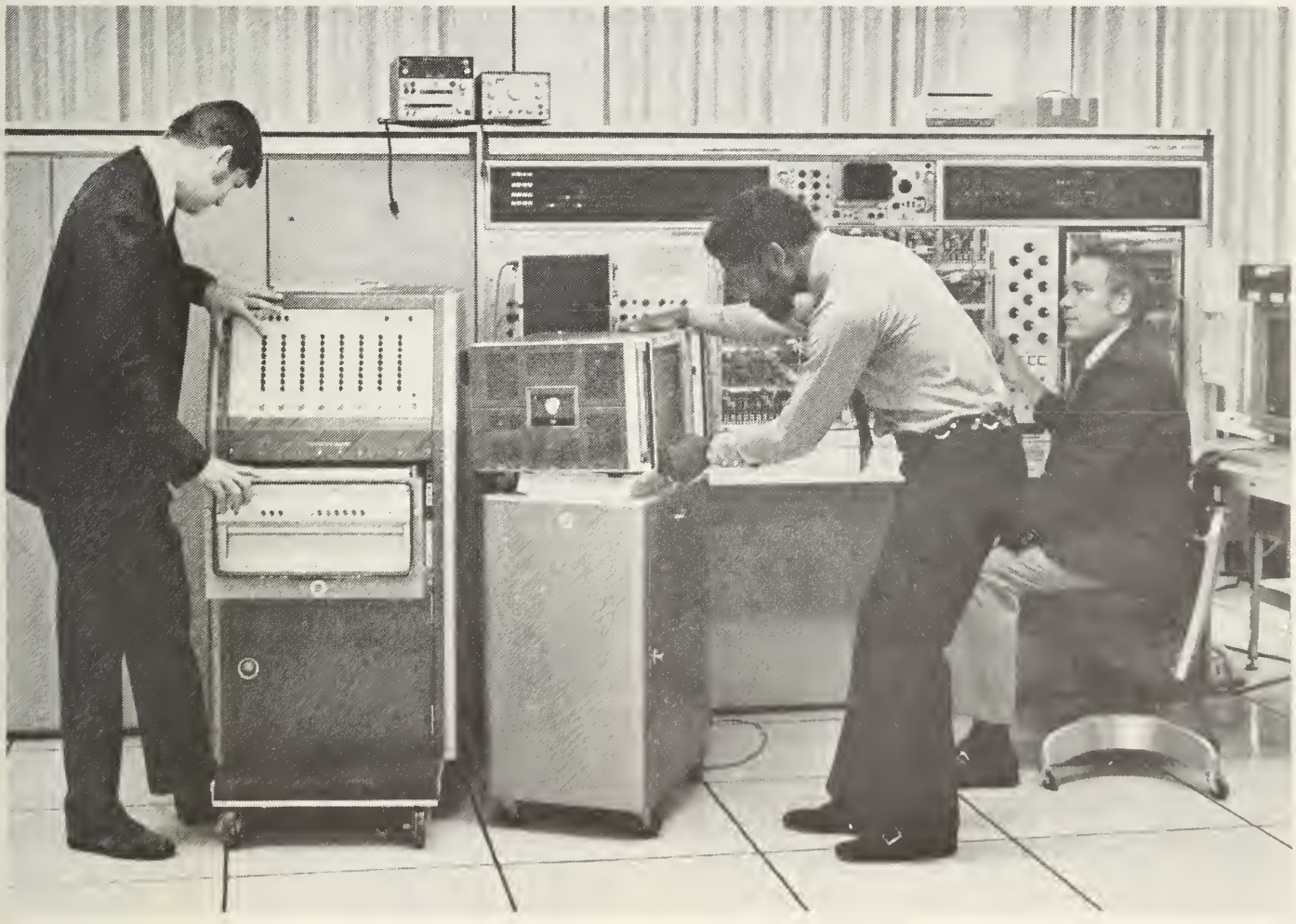
**EE 4484 Electronic Warfare Systems (3-2).**
This course covers electronic warfare in that portion of the electromagnetic spectrum through the millimeter wavelength region. The infrared through electro-optic region is covered in a companion course, EE 4423. Electronic denial and deceptive countermeasures against fuses, communications, and various radar detection and tracking systems are discussed. Equations for required jammer gain and power output are developed. The characteristics of passive countermeasures are discussed. Other topics include anti-radiation missiles, counter-countermeasure circuits, target masking and modification, signal intercept, signal sorting, signal identification, and direction finding. Techniques are discussed in relation to U.S., allied, and communist bloc systems. Laboratory work reinforces the classroom discussions. PREREQUISITES: EE 4434, SECRET clearance and U.S. Citizenship.

**EE 4489 Electronic Warfare and C3 Systems (4-0).**
This course examines the disabling potential of electronic warfare against command, control and communication systems. A thorough background in electronmagnetic propagation, passive and radiating antenna systems, as well as in scattering structures is developed and applied to military systems at selected frequencies from ELF through optical. Counter and counter-countermeasure principles, techniques and effectiveness are examined in detail. PREREQUISITES: EE 3714, SECRET clearance and U.S. Citizenship.

**EE 4540 Telecommunications Networks (4-0).**
Transmission of digital data, to include modulation/demodulation and error detection/correction techniques. Multiple access via line switching, packet switching, and ALOHA techniques. Analysis of queuing, blocking, delay and thruput. Protocol requirements, routing, and flow control in large-scale interconnected systems. Subnetwork compart-

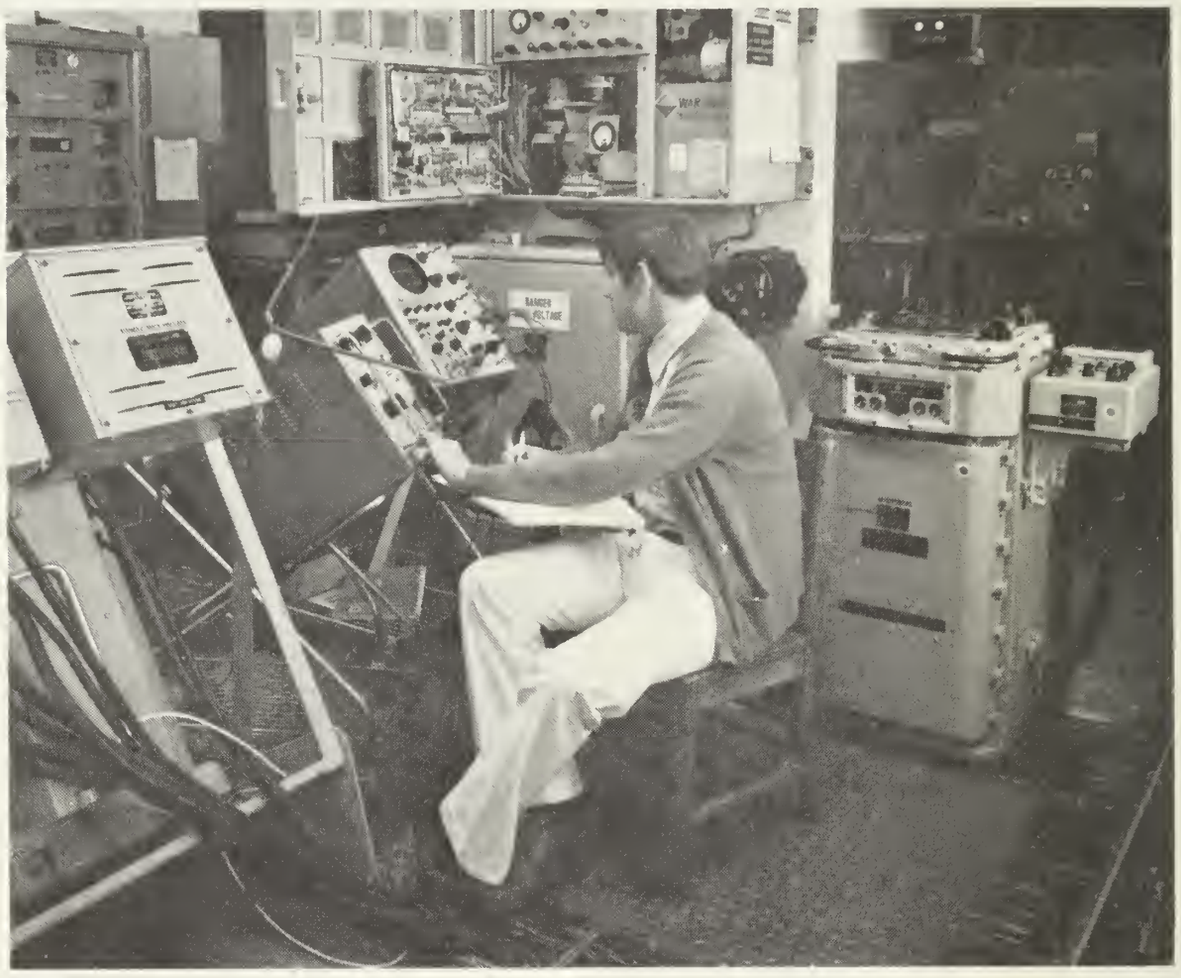
mentalization, digitized voice, and network reliability. Examples of existing and proposed systems. PREREQUISITE: EE 4489 or equivalent.

**EE 4716 Signal Processing Systems (4-1).**
A study of digital, analog, and hybrid signal processing systems for communications, echo ranging, and electronic surveillance. Examples from current and proposed military systems will be analyzed. This course is designed for the ASW and EW curricula. PREREQUISITE: EE 3714.



*Part of the computer facilities at the Postgraduate School.*

# ELECTRONIC WARFARE



*The radar laboratory, one of many used by electronic warfare students.*

The Electronic Warfare Academic Group has administrative responsibility for the academic content of the Electronic Warfare Systems Technology curriculum. Teaching in this multi-disciplinary program is carried out by faculty members attached to the following academic departments: Computer Science, Electrical Engineering, Mathematics, Meteorology, National Security Affairs, Operations Research, and Physics and Chemistry. Members of the Academic Group are:

**David Boysen Hoisington**, Professor of Electronics; Chairman (1947)*, B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

**Eugene Casson Crittenden, Jr.**, Distinguished Professor of Physics (1953); B.A., Cornell Univ., 1934; Ph.D., 1938.

**John Norvell Dyer**, Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

**Jeffrey Bruce Knorr**, Associate Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

**William Reese**, Professor of Physics (1963); B.A. Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

**Norman Floyd Schneidewind**, Professor of Information Science and Computer Science (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960;

M.S.O.R. (ENGR), 1970; D.B.A., 1966.

**Alan Robert Washburn**, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

**Carroll Orville Wilde**, Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master of Science in Systems Technology will be awarded at the completion of a multidisciplinary program, Curriculum 595, satisfying the following degree requirements:
   a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included, and in three disciplines, a course at the 4000 level must be included.
   b. An approved sequence of at least three courses constituting advanced specialization in one area must be included.
   c. In addition to the 45 hours of course credit, an acceptable thesis must be completed.

### SYSTEMS TECHNOLOGY

ST 0002 Seminar (0-1).
Special lectures and discussion of matters related to the EW program. PREREQUISITE: SECRET clearance.

ST 0810 Thesis Research/Group Project (0-0).
Students in the Systems Technology curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

*Upper Division or Graduate Courses*

ST 3020 Electronic Warfare Computer Applications (3-2).
Application of digital and analog techniques to the recording, processing, display, and interpretation of electronic warfare signals and data. The computer is applied to the solution of electronic warfare problems such as signal identification, and to problems encountered in operational test and evaluation. PREREQUISITES: CS 3510, EE 4484, OS 3655, OS 3208, OS 4653 (may be taken concurrently).

ST 3350 Signal Intelligence and the Threat Environment (4-0).
This course focuses on the current threat environment within which the U.S. Navy operates; U.S. signal intelligence capabilities for countering the threat; and the process for designing new U.S. countermeasure systems. The threat focus will specifically be on the Soviet Navy as the U.S. Navy's most formidable opponent in the foreseeable future. PREREQUISITES: SI clearance and U.S. Citizenship; registration in EW curriculum #595 or consent of Instructor.

*Graduate Course*

ST 4453 Underwater Sound, Systems, and Countermeasures (3-2).
A study of the principles of underwater sound propagation, and the design and operational characteristics of underwater sound systems. Emphasis is placed on various measures used to interfere with and to deceive active and passive Sonar systems, and the techniques used to counter this interference. Topics studied include: sensor arrays, acoustic propagation, noise, acoustic quieting, signal processing, and examples of active and passive underwater acoustic systems, including acoustic countermeasures. PREREQUISITES: PH 2123, SECRET clearance and U.S. Citizenship.

# ENGINEERING ACOUSTICS

The academic character of programs in Engineering Acoustics is interdisciplinary, with courses drawn principally from the fields of electrical engineering and physics. Although broadly based, the emphasis is on those aspects of acoustics concerning propagation of sound in the oceans, on applications of underwater sound and on the electrical engineering of instrumentation for detection of underwater sounds. These programs are designed for students in the Underwater Acoustics Curriculum.

The academic aspects of the programs are the responsibility of a committee, chaired by O. B. Wilson, Jr., Professor of Physics, with G. S. Sackman, Associate Professor of Electrical Engineering, as a member.

## DEGREE REQUIREMENTS MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

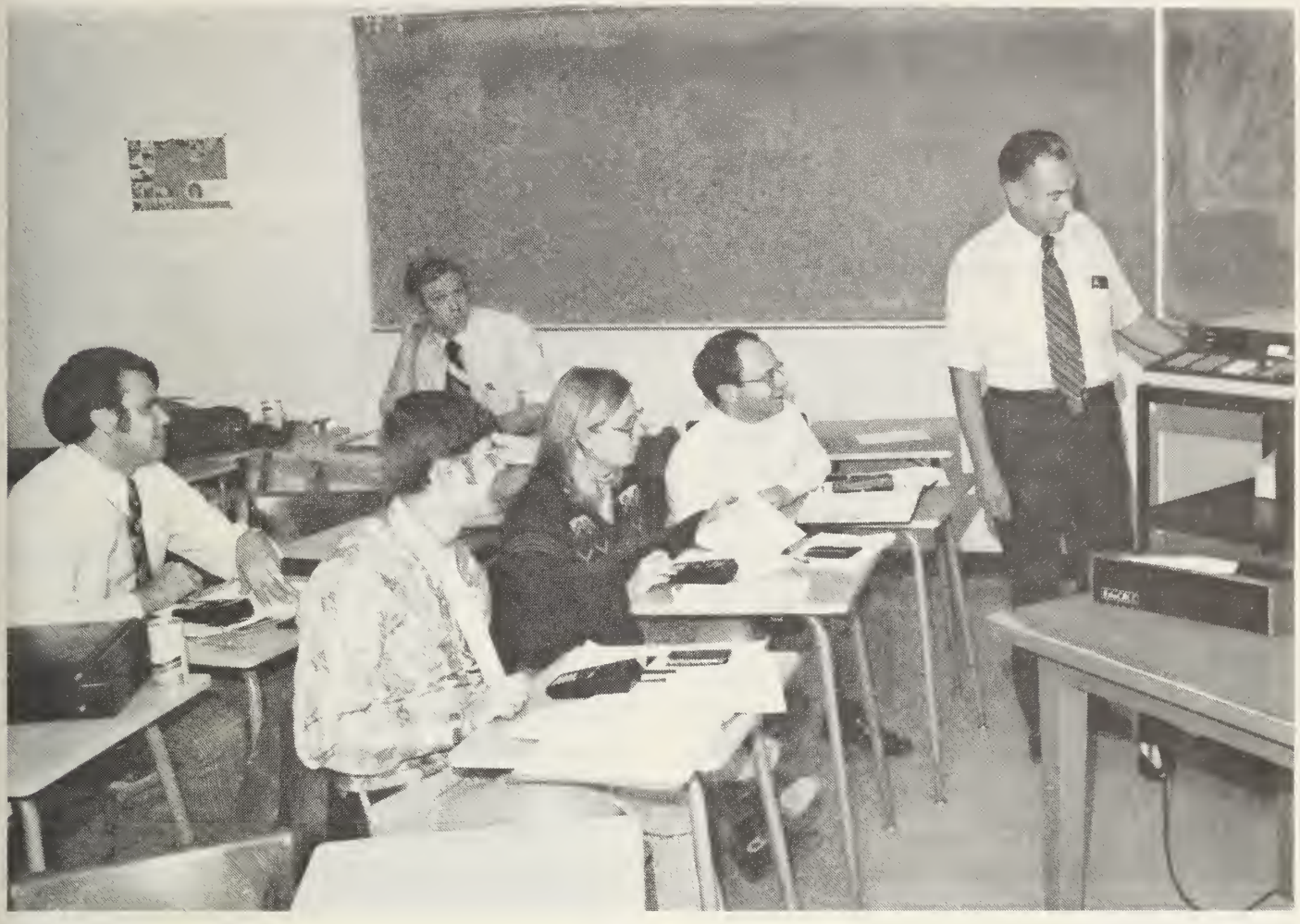
1. A student pursuing a program leading to a Master of Science in Engineering Acoustics must have completed work which would qualify him for a Bachelor of Science degree in engineering or physical science. Credit requirement for the Master of Science degree must be met by courses in addition to those used to satisfy this requirement.

2. The Master of Science in Engineering Acoustics requires a minimum of 36 graduate credit quarter hours of course work; at least 20 graduate quarter hours must be taken in acoustics and its applications. One 4000 level course from each of three of the following areas must be included: wave propagation, vibration and noise control, transducer theory, sonar systems, and signal processing.

3. An acceptable thesis must be completed.

4. Approval of each program by the Engineering Acoustics Academic Committee.

# DEPARTMENT OF MATHEMATICS



*Students get hands-on use of calculators in their classwork.*

**Carroll Orville Wilde,** Professor of Mathematics; Chairman (1968)*; B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

**Craig Comstock,** Professor of Mathematics (1970); B.E.P., Cornell Univ., 1956; M.S., Naval Post-graduate School, 1961; Ph. D., Harvard Univ., 1965.

**Frank David Faulkner,** Distinguished Professor of Mathematics (1950); B.S., Kansas State Teachers College, 1940; M.S., Kansas State College, 1942; Ph.D., Univ. of Michigan, 1969.

**Richard Homer Franke,** Associate Professor of Mathematics (1970); B.S., Fort Hays Kansas State College, 1959; B.S., Univ. of Utah, 1961; Ph.D., 1970.

**Robert Eugene Gaskell,** Professor of Mathematics (1966); A.B., Albion College, 1933; M.S., Univ. of Michigan, 1934; Ph.D., 1940.

**Toke Jayachandran,** Associate Professor of Mathematics (1967); B.S., V.R. College, Nellore, India, 1951; M.S., Univ. of Wyoming, 1962; Ph.D., Case Institute of Technology, 1967.

**Ladis Daniel Kovach,** Professor of Mathematics (1967); B.S., Case Institute of Technology, 1936; M.S., 1948; M.A., Western Reserve Univ., 1940; Ph.D., Purdue Univ., 1951.

**Brooks Javins Lockhart,** Professor of Mathematics (1948); B.A., Marshall Univ., 1937; M.S., West Virginia Univ., 1940; Ph.D., Univ. of Illinois, 1943.

**Kenneth Robert Lucas,** Associate Professor of Mathematics (1958); B.S., Washburn Univ., 1949; Ph.D., Univ. of Kansas, 1957.

**Herman Bernhard Marks,** Associate Professor of Mathematics (1961); B.S., Southern Methodist Univ., 1950; M.A., Univ. of Texas, 1959.

**George William Morris,** Professor of Mathematics (1968); B.A., Southwestern Institute of Technology, 1942; M.A., Univ. of Oklahoma, 1947; Ph.D., Univ. of California at Los Angeles, 1957.

**Ira Bert Russak,** Associate Professor of Mathematics (1972); M.E., Stevens Institute of Technology, 1957; M.A., Univ. of California at Los Angeles, 1962; Ph.D., 1967.

**Arthur Loring Schoenstadt,** Associate Professor of Mathematics (1970); B.S., Rensselaer Polytechnic Institute, 1964; M.A., 1965; Ph.D., 1968.

**Elmo Joseph Stewart,** Professor of Mathematics (1955); B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Univ., 1953.

**Donald Herbert Trahan,** Associate Professor of Mathematics (1966); B.S., Univ. of Vermont, 1952; M.A., Univ. of Nebraska, 1954; Ph.D., Univ. of Pittsburgh, 1961.

**Peter Cheng-Chao Wang,** Associate Professor of Mathematics (1970); B.A., Pacific Lutheran Univ., 1961; M.A., Wayne State Univ., 1962; Ph.D., 1966.

**Maurice Dean Weir,** Associate Professor of Mathematics (1969); B.A., Whitman College, 1961; M.S., Carnegie-Mellon Univ., 1963; D.A., 1970.

## EMERITUS FACULTY

**Willard Evan Bleick,** Professor Emeritus (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

**Joseph Giarratana,** Professor Emeritus (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

**Carl Adolf Hering,** Professor Emeritus (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

**John Philip Pierce,** Professor Emeritus (1948); B.S.E.E., Worcester Polytechnic Institute, 1931; M.S.E.E., Polytechnic Institute of Brooklyn, 1937.

**James Woodrow Wilson,** Professor Emeritus (1949); B.A., Stephen F. Austin State, 1935; B.S. in Ch.E., Univ. of Texas, 1939; M.S. in Ch.E., Texas A&M College, 1941.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MATHEMATICS

The Department of Mathematics offers The Master of Science degree to qualified students. An interested student should consult the Chairman of the Mathematics Department for an evaluation of his previous academic record to determine his potential for successfully completing a degree program.

If the student's previous record is found to be adequate, a mathematics program is designed which satisfies the Departmental requirements and fits the interest, preparation and aptitude of the student. The program, and subsequent changes in the program, must be approved by the Departmental Chairman.

A student whose background is deemed insufficient for entrance may take courses to reach entrance level, however such courses cannot be countered toward degree requirements.

## MASTER IN SCIENCE IN APPLIED MATHEMATICS

1. In order to enter a program leading to the degree Master of Science in

Applied Mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics or, with a strong mathematical orientation, in a physical science or engineering.

2. A program that leads to the degree Master of Science in Applied Mathematics for a student who has met the entrance criteria must contain a minimum of 45 quarter hours of graduate level courses with a minimum QPR of 3.0, subject to the following conditions:

a. The program must be approved by the Chairman of the Department of Mathematics.

b. The program must include at least fifteen hours at the 4000 level, with at least twelve hours in 4000 level mathematics courses.

c. The program must contain at least nine hours in an approved sequence of applications courses from outside the Mathematics Department, and at least nine hours in an approved sequence of courses from within the Mathematics Department.

d. An acceptable thesis is normally required and is credited as the equivalent of nine hours of 3000 level mathematics courses. (A student may petition the Chairman of the Mathematics Department to substitute nine hours of courses for the thesis.)

e. Courses in the following areas are specifically required in any program; some of these courses may be used to satisfy part (or all) of the mathematics sequence requirement in item (2.c.) above:

(1) Real/complex analysis (a two-course sequence), or applied algebra (a two-course sequence)

(2) Ordinary and/or Partial Differential Equations and Integral Transforms

(3) Numerical Analysis

(4) Probability and Statistics

## MASTER OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. In order to pursue a program leading to the Master of Science degree with major in mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics.

2. A curriculum which satisfies the Master of Science degree requirements consists of a minimum of 45 quarter hours of approved courses in mathematics and related subjects. An acceptable thesis may be counted as equivalent to nine quarter hours. A student must have a QPR of 3.0 or greater in any major program.

3. At the discretion of the Chairman of the Department of Mathematics, a student pursuing a program leading to the Master of Science degree with major in mathematics may (or may not) be required to write a thesis in mathematics.

4. The following topics are specifically included in any major program.

a. 6 hours of Algebra

b. 6 hours of Analysis

5. The main areas of thesis topics are

a. Computer Science

b. Differential Equations

c. Fourier Analysis

d. Functional Analysis

e. Numerical Methods

f. Optimal Control

g. Probability and Statistics

h. Tensor Analysis and Applications

## MATHEMATICS

**MA 0112 Refresher Mathematics (5-5).**
Calculus Review.

**MA 0113 Refresher Mathematics (5-5).**
Algebra review.

**MA 0114 Refresher Mathematics (5-5).**
Pre-calculus review.

**MA 0125 Logic And Set Theory (5-0).**
An introduction to the elements of set theory and mathematical reasoning. Sets, Venn Diagrams, truth tables, quantifiers, logical reasoning. Functions, relations, partitions and equivalence relations, 1-1 correspondence. (Paradoxes of set theory, axiom of choice.) PREREQUISITE: None.

**MA 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

*Lower Division Courses*

**MA 1021 Precalculus Mathematics (4-0).**
Brief review of algebraic fundamentals. Algebra of complex numbers, quadratic equations. Systems of equations. Trigonometric functions of the general angle. Identities. Solution of right triangles. Elements of the theory of equations. Introduction to analytic geometry. PREREQUISITES: None.

**MA 1115 Single Variable Calculus (5-0).**
Review of analytic geometry and trigonometry, functions of one variable, limits, derivatives, continuity and differentiability; differentiation of algebraic, trigonometric, logarithmic and exponential functions with applications to maxima and minima, rates, differentials; product rule, quotient rule, chain rule; antiderivatives, integrals and the fundamental theorem of calculus; definite integrals, areas, lengths of curves and physical applications; special methods of integration. PREREQUISITE: Precalculus mathematics. (May be taken through Continuing Education as the minicourse sequence MA 1131-36)*

**MA 1116 Multivariable Calculus (5-0).**
Review of calculus of one variable; vector algebra and calculus, directional derivative, gradient and integral theorems; maxima and minima of functions of two independent variables, total differential; double and triple integrals, cylindrical and spherical coordinate systems; infinite series, convergence tests, uniform convergence and Taylor series. PREREQUISITE: Previous course in calculus. (May be taken through Continuing Education as the minicourse sequence MA 1137-40)*

**MA 1117 Calculus Laboratory I (0-2).**
A problem solving course associated with MA 1115.

**MA 1118 Calculus Laboratory II (0-2).**
A problem solving course associated with MA 1116.

**MA 1119 Selected Calculus Topics Review (2-1).**
Functions, limits, continuity, differentiation of functions of one variable and several variables. Implicit functions, Parametric equations, optimization. Definite, indefinite and multiple integrals. Sequences and series, series representation of functions, Euler's formula. PREREQUISITE: A previous course in calculus.

**The minicourses are described in the Continuing Education catalog.*

*Upper Division Courses*

**MA 2025 Logic, Sets And Functions (4-0).**
Propositional logic, elements of set theory, relations, functions and partitions. An introduction to theorem proving techniques, including mathematical induction, in the context of basic mathematical systems. PREREQUISITE: None.

**MA 2040 Matrix Algebra (2-0).**
Linear equations, systems of linear equations, determinants, matrices and vectors, addition and multiplication of matrices, inverse of a matrix, partitioned matrices, vector spaces and subspaces, rank of a matrix. This course is designed primarily for students in management. PREREQUISITE: College algebra.

**MA 2042 Linear Algebra (4-0).**
Systems of linear equations, matrices, and determinants. Finite dimensional vector spaces, linear dependence, basis, dimension, inner products, orthogonalization. Linear transformations, rank and nullity, change of basis, linear functionals, orthogonal transformations, quadratic forms, symmetric matrices, diagonlization, eigenvalues and eigenvectors. PREREQUISITES: MA 1116.

**MA 2045 Computational Matrix Algebra (3-0).**
Systems of Linear algebraic equations, Matrix algebra and determinants. Numerical methods in linear algebra. Vector spaces. Rank, Inverse by Gauss' method. Characteristic equations, roots and vectors — numerical methods. PREREQUISITE: None. (May be taken through Continuing Education as the minicourse sequence MA 2055-56-57.)

**MA 2047 Linear Algebra and Vector Analysis (4-0).**
Solutions of linear systems of equations, algebra of matrices, determinants. Linear vector spaces, linear dependence and independence, subspaces, bases and dimension. Inner products, ortho-normal bases and Gram-Schmidt process. Eigenvectors and eigenvalues. Least squares. The algebra and calculus of vectors in $R^2$ and $R^3$. Del operator, directional derivative, gradient, divergence and curl with applications. Line, surface and volume integrals, Green's, Stoke's and divergence theorems. PREREQUISITE: A previous course in calculus to include multiple integrals.

**MA 2048 Linear Algebra and Vector Analysis (5-0).**
Algebra of matrices. Determinants. Elementary matrices, rank of matrix and inverse of a matrix. Linear vector spaces, subspaces, linear dependence and independence, basis and dimension. Systems of homogeneous and non-homogeneous linear equations and their solutions. Eigenvalues and vectors in $R^2$ and $R^3$. Calculus of these vectors. Del operator, directional derivative, gradient, divergence and curl with applications. Vector integration, line integrals, surface and volume integrals. Green's, Stokes' and the Divergence Theorem. PREREQUISITE: MA 1116 or equivalent.

**MA 2110 Multivariable Calculus (4-0).**
Integrated with linear algebra. Functions of several variables, continuous transformations, jacobians, chain rule, implicit function theorem, inverse function theorem, extrema, Lagrange multiplier technique, curvilinear coordinates. PREREQUISITE: MA 1116 or equivalent, MA 2042 or equivalent concurrently.

**MA 2121 Differential Equations (4-0).**
Ordinary differential equations: homogeneous and nonhomogeneous equations, linear independence of solutions, linear and nonlinear equations, power series solutions, systems of differential equations, applications. PREREQUISITE: MA 1116 or equivalent, MA 2045 or equivalent concurrently.

**MA 2125 Differential Equations (3-0).**
An abbreviated version of MA 2121, without Laplace transforms or power series. PREREQUISITE: MA 1116 or equivalent, MA 2045 or equivalent concurrently.

**MA 2129 Ordinary Differential Equations and Laplace Transforms (2-1).**
First order ordinary differential equations, second order equations with constant coefficients, application, LaPlace Transforms. PREREQUISITE: Differential and integral calculus.

**MA 2161 Introduction to Mathematical Physics (5-0).**
An introduction to the techniques used in solving problems in classical field theories. Vector and scalar fields are studied. Potential fields for fluid flow using curvilinear coordinates. Vector field theory. Analytic functions of a complex variable. Residue theory with application to Fourier and Laplace transforms. Conformal mapping. PREREQUISITE: MA 1116 and MA 2121 (the latter may be taken concurrently).

**MA 2172 Complex Variables (4-0).** Analytic functions, integration and series representations. Residue theory and applications applied to ordinary and partial differential equations; convolution theorems. PREREQUISITE: MA 2121.

MA 2181 Vector Calculus (2-1). Differentiation and integration of vector functions. The del operator and related concepts. Green's theorem, Stokes' theorem, divergence theorem. Interpretations and applications. PREREQUISITE: Calculus and vector algebra.

MA 2232 Numerical Methods (3-1).
Error propagation. Evaluation of functions. Non-linear equations. Linear algebra for computers. Interpolation. Least squares approximation. Numerical integration. Ordinary differential equations. PREREQUISITE: MA 2121 and CS 0110 or equivalent.

MA 2300 Mathematics for Management (5-0).
This course is designed to provide a mathematical basis for modern managerial tools and techniques. It includes elements of differential and integral calculus, sequences and series and an introduction to matrix algebra. PREREQUISITE: College algebra.

MA 2305-2306 Calculus I-II (3-0), (2-0).
A two course sequence in calculus designed primarily for students in Administrative Science. Brief review of algebra; differential calculus of power functions, logarithmic functions and exponential functions; multivariable calculus, maxima and minima with and without constraints. Integral calculus of power functions, logarithmic functions and exponential functions. Applications will be from the field of economics and management. PREREQUISITE: College algebra.

MA 2310-2311 Mathematics for Naval Intelligence I-II (5-3) and (5-2).
A review of linear, logarithmic, sinusoidal and exponential functions, with graphical emphasis; differentiation and integration, with both analytical and numerical procedures, continuation to include introductory treatments of Fourier analysis; the Fourier integral, spectral analysis, differential equations and the Laplace transformation. Descriptive statistics and data presentation, discrete probability and the binomial and Poisson distributions, continuous probability, the normal distribution and the central limit theorem, hypothesis testing, estimation and correlation, small samples. Students' t-distribution, the Chi-square distribution. Single and multiple regression, computation, data processing and analysis. PREREQUISITE: College algebra and trigonometry.

MA 2400 Introduction to Vectors, Matrics and Vector Calculus (3-0).
The algebra of vectors and matrices. Systems of linear equations, determinants; eigenvalues. Directional derivative, gradient, divergence, curl; line, surface and volume integrals; integral theorems; applications. PREREQUISITE: Differential and integral calculus.

MA 2401 Introduction to Differential Equations and Complex Functions (4-1).
Ordinary differential equations including series solutions and Laplace transforms; Fourier series and partial differential equations; complex analytic functions. PREREQUISITE: Differential and integral calculus.

*Upper Division or Graduate Courses*

MA 3026 Topics in Discrete Mathematics (4-0).
Properties of algebra structures; elementary concepts of semigroups, monoids and groups. Introduction to lattices and graph theory. Applications to computer science and communication theory. PREREQUITIE: MA 2025 or consent of Instructor.

MA 3046-3047 Linear Algebra I-II (3-0).
Special types of matrices; orthogonal reduction of a real symmetric matrix to diagonal form; gradratic forms and reductions to expressions involving only squares of the variables; applications to maxima and minima; Lambda matrices and related topics; Cayley-Hamilton theorem. Reduced characteristic function; canonical forms, idempotent and nilpotent matrices; solutions to matrix polynomial equations; functions of a square matrix; applications such as to differential equations, stability criteria. PREREQUISITE: MA 2045.

MA 3130 Differential Equations (4-0).
Review of linear ordinary differential equations. Separation of variables for partial differential equations. Fourier Series and orthogonal functions. Series solutions and special functions. Boundary value problems in two and three dimensions. PREREQUISITE: MA

1116, MA 2400 and ordinary differential equations.

**MA 3132 Partial Differential Equations and Integral Transforms (4-0).**
Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier, Bessel and Legendre series solutions, Laplace and Fourier transforms; classification of second order equations; applications. PREREQUISITE: MA 2121 or equivalent.

**MA 3139 Fourier Analysis and Partial Differential Equations (4-0).**
Solution of the one-, two-, and three-dimensional wave equations by separation of variables and characteristics; ray propagation; Fourier analysis applied to ordinary and partial differential equations; convolution therorems. PREREQUISITE: MA 2129.

**MA 3181 Vector Analysis (3-0).**
Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems; applications in various fields of engineering. PREREQUISITE: MA 1116 or equivalent.

**MA 3185 Tensor Analysis (3-0).**
Definition of a tensor. Algebra of tensors. The metric tensor. The geometric representation of vectors in general coordinates. The covariant derivative and its application to geodesics. The Reimann tensor, parallelism, and curvature of space. PREREQUISITE: Consent of Instructor.

**MA 3232 Numerical Analysis (3-2).**
Solution of nonlinear equations, zeros of polynomials. Interpolation and approximation. Numerical differentiation and quadrature. Matrix manipulations; linear simultaneous algebraic equations, eigenvalues. Numerical solutions of ordinary differential equations. Analysis of computational errors. PREREQUISITE: MA 2121 or equivalent (may be taken concurrently) and FORTRAN programming.

**MA 3243 Numerical Methods for Partial Differential Equations (4-1).**
Finite difference approximations for derivatives. Truncation and discretization errors. Parabolic and hyperbolic equations. Explicit and implicit methods. The Crank-Nicolson method. Approximations at irregular boundaries. Elliptic equations. The Liebmann method. Systems of partial differential equations. Students are expected to write FORTRAN programs for the above methods. A term project involving the solution of a suitably difficult boundary value problem is required. PREREQUISITE: MA 3132, CS 2700 or equivalent.

**MA 3362 Orbital Mechanics (3-0).**
Review of kinematics, Lagrange's equation of motion. The earth's gravitational field. Central force motion. The two body problem. Perturbations. PREREQUISITE: A course in dynamics.

**MA 3560 Modern Applied Algebra (3-0).**
An introductory course in the techniques and tools of abstract algebra with special emphasis on applications to coding theory, radar and communications systems, and computer science. Elements of set theory, equivalence relations and partitions. Semigroups, groups, subgroups and homomorphisms. Rings, ideals and fields. Directed graphs and lattices. Applications may vary. PREREQUISITE: Consent of Instructor.

**MA 3565 Modern Algebra I (3-0).**
An advanced course in the subject of abstract algebra. Semigroups, groups, subgroups, normal subgroups. Groups acting on sets, operator groups. The Jordan-Holder Theorem, solvable groups. The Krull Schmidt Theorem. PREREQUISITE: MA 3560 or consent of Instructor.

**MA 3605-3606 Fundamentals of Analysis I-II (3-0).**
Elements of set theory, the real number system, and the usual topology of En; properties of continuous functions; differential of vector-valued functions, Jacobians, and applications (implicit function, inverse function theorem, extremum problems). Functions of bounded variation and theory of Reimann-Stieltjes integration, multiple and iterated integrals, convergence theorems for sequences and series of functions. PREREQUISITE: Consent of Instructor.

**MA 3610 Introduction to General Topology (3-**

0).
Topologies, bases and subbases, compactness and connectivity. Moore-Smith convergence theorems. Metrization and embedding theorems, uniform structures. Tychonoff product theorem, Alexandroff and Stone-Cech compactification. PREREQUISITE: MA 3605.

**MA 3675-3676 Theory of Functions of a Complex Variable I-II (3-0).**
Selected topics from the theory of functions of a real variable; complex functions, power series, laurent series. Singularities of complex functions; residues and contour integration; zeros of analytic functions, factors of and infinite product representation for analytic functions; maximum modulus theorems for analytic and harmonic functions; conformal mapping. PREREQUISITE: Consent of Instructor.

**MA 3730 Theory of Numerical Computation (3-0).**
Analysis of computational methods used for the solution of problems from the areas of algebraic equations, polynomial approximation, numerical differentiation and integration, and numerical solution of ordinary differential equations. PREREQUISITE: Consent of Instructor.

*Graduate Courses*

**MA 4237 Advanced Topics in Numerical Analysis (4-0).**
The subject matter will vary according to the abilities and interest of those enrolled. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

**MA 4393 Topics in Applied Mathematics (3-0).**
A selection of topics in applied mathematics. The course content varies. Credit may be granted for taking this course more than once. PREREQUISITE: Consent of Instructor.

**MA 4501 Topics in Foundations of Mathematics (3-0).**
A selection of topics in foundations of mathematics. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

**MA 4566 Modern Algebra II (3-0).**
A continuation of MA 3565. Rings, ring homomorphism, integral domains and euclidean domains. Unique factorization rings, polynominal rings. Modules and ideals. Noetherian rings, Field extension and Galois theory. PREREQUISITE: MA 3565.

**MA 4593 Topics in Algebra (3-0).**
A selection of topics in algebra. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

**MA 4610 Topology of Dynamical Systems (3-0).**
Dynamical systems, trajectories, limiting sets, recursive concepts, dispersive concepts, stability theory. PREREQUISITES: MA 2121 and either MA 3605 or MA 3610.

**MA 4611 Calculus of Variations (3-0).**
Bliss differential methods, Euler equations, Weierstrass-maximum principle, Legendre conditions. Perturbation techniques, numerical procedures for determining solutions, and applications to engineering and control problems. PREREQUISITE: MA 2121 (programming experience desirable).

**MA 4620 Theory of Ordinary Differential Equations (3-0).**
Introduction to the modern theory of ordinary differential equations. Systems of equations. Theoretical and constructive methods of solutions. PREREQUISITE: Consent of Instructor.

**MA 4622-4623 Principles and Techniques of Applied Mathematics I-II (3-0).**
Linear operators, generalized functions and Hilbert spaces; solutions of partial differential equations by eigenfunctions; variational techniques and their applications to eigenfunctions; integral equations, Laplace, Fourier and other transforms, including their inversion in the complex plane as applied to partial differential equations; method of characteristics for hyperbolic equation. PREREQUISITES: MA 3132 or equivalent and MA 2172 or equivalent.

**MA 4635-4636 Functions of Real Variables I-II (3-0).**
Axiomatic set theory, development of the real

numbers, semi-continuous functions, absolutely continuous functions, functions of bounded variation; classical Lebesgue measure and integration theory, convergence theorems and Lp spaces. Abstract measure and integration theory, signed measures, Radon-Nikodym theorem; Lebesgue decomposition and product measure; Daniell integrals and integral representation of linear functionals. PREREQUISITE: MA 3606.

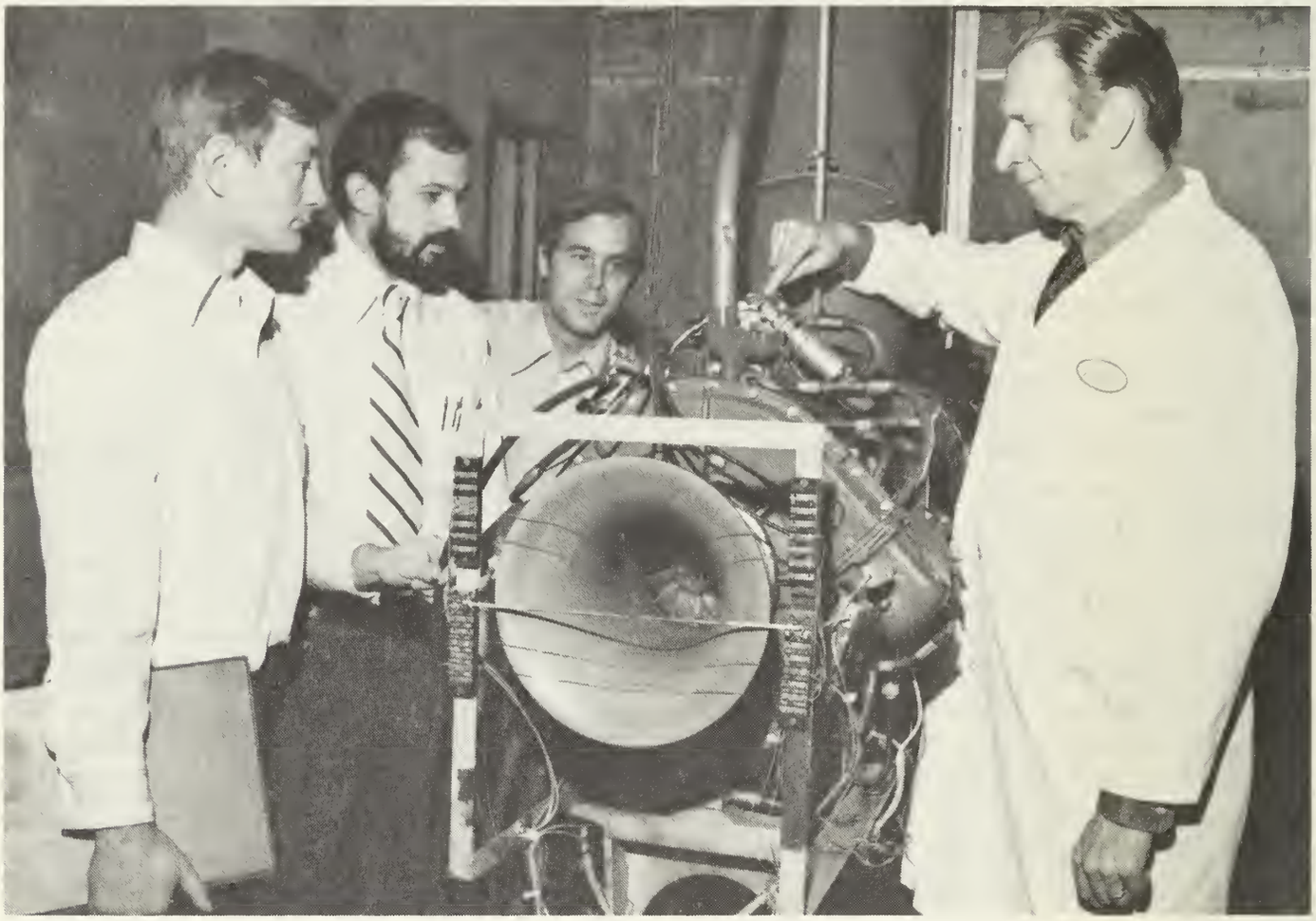
**MA 4637 Introduction to Functional Analysis (3-0).**
An introduction to Banach and Hilbert spaces, including open mapping-closed graph theorem, weak and weak star topologies, spectral theorems for compact Hermitian operators. Hermitian bounded and normal bounded operators. PREREQUISITE: MA 4636.

**MA 4672 Integral Transforms (3-0).**
The Laplace, Fourier and Hankel transforms and their inversions. Applications to problems in engineering and physics. PREREQUISITE: MA 2172.

**MA 4693 Topics in Analysis (3-0).**
A selection of topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

**MA 4872 Topics in Calculus of Variations (3-0).**
Recent development of the numerical solution of problems in the calculus of variations. Foundations of numerical methods, applications to control problems. Differentials, perturbations, variational equations, adjoint system, conditions for optimum. Euler equations, maximum principle of Weierstrass and Pontryagin, the Legendre condition. Methods of solution: spectral variations, variation of extremals, dynamic programming. Applications in ship routing and missile control. PREREQUISITES: MA 2121, MA 3046 and computer programming or Consent of Instructor.

# DEPARTMENT OF MECHANICAL ENGINEERING



*Students learn about the operation of gas turbines.*

**Paul James Marto,** Professor of Mechanical Engineering; Chairman (1965)*; B.S., Univ. of Notre Dame, 1960; M.S., in Nuc. Engr., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

**John Edison Brock,** Professor of Mechanical Engineering (1954); B.S.M.E., Purdue Univ., 1938; M.S.E., 1941; Ph.D., Univ. of Minnesota, 1950.

**Gilles Cantin,** Professor of Mechanical Engineering (1960); B.A. Sc., Ecole Polytechnique at Montreal, 1950; M. Sc., Stanford Univ., 1960; Ph.D., Univ. of California at Berkeley, 1968.

**Thomas Edward Cooper,** Associate Professor of Mechanical Engineering (1970); B.S., Univ. of California at Berkeley, 1966; M.S.M.E., 1967; Ph.D., 1970.

**Allen Eugene Fuhs,** Distinguished Professor of Mechanical Engineering (1966); B.S.M.E., Univ. of New Mexico, 1951; M.S.M.E., California Institute of Technology, 1955; Ph.D., 1958.

**Clarence Jimmy Garrison,** Associate Professor of Mechanical Engineering (1970); B.S.M.E., Univ. of Nebraska, 1960; M.S. M.E., 1962; Ph. D., Univ. of Washington, 1968.

**Thomas Michael Houlihan,** Associate Professor of Mechanical Engineering (1969); B.M.E., Manhattan College, 1961; Ph.D., Syracuse Univ., 1968.

**Matthew Dennis Kelleher,** Associate Professor of Mechanical Engineering (1967); B.S. Univ. of Notre Dame, 1961; M.S.M.E., 1963, Ph.D., 1966.

**Terry Robert McNelley,** Assistant Professor of Materials Science (1976); B.S. M.E., Purdue Univ., 1967; Ph.D., Stanford Univ., 1973.

**Robert Eugene Newton,** Professor of Mechanical Engineering (1951); B.S.M.E., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

**Dong Huu Nguyen,** Associate Professor of Mechanical Engineering (1969); B.S. M.E., Purdue Univ., 1960; M.S. in Nuc. Eng., 1961; Ph.D., Univ. of California at Berkeley, 1965.

**Robert Harry Nunn,** Associate Professor of Mechanical Engineering (1968); B.S., Univ. of California at Los Angeles, 1955; M.S.M.E., 1964; Ph.D., Univ. of California at Davis, 1967.

**Arthur Jeffery Perkins,** Associate Professor of Materials Science (1972); B.S., Drexel Institute of Technology, 1965; M.S., Case Institute of Technology, 1967; Ph.D., in Metallurgy, Case Western Reserve University, 1969.

**Paul Francis Pucci,** Professor of Mechanical Engineering (1956); B.S., Purdue Univ., 1949; M.S.M.E., 1950; Ph.D., Stanford Univ., 1955.

**David Salinas,** Associate Professor of Mechanical Engineering (1970); B.S., Univ. of California at Los Angeles, 1959; M.S., 1962; Ph.D., 1968.

**Turgut Sarpkaya,** Distinguished Professor of Mechanical Engineering (1967); M.S.M.E., Tech. Univ. of Istanbul, 1951; Ph.D., Univ. of Iowa, 1954.

## EMERITUS FACULTY

**Roy Walters Prowell,** Professor Emeritus (1946); B.S. in I.E., Lehigh Univ., 1936; M.S.M.E., Univ. of Pittsburgh, 1943.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

A specific curriculum must be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Chairman of the Department of Mechanical Engineering at least two quarters before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

## MASTER OF SCIENCE IN MECHANICAL ENGINEERING

1. Undergraduate Preparation. A candidate shall have completed work equivalent to the Bachelor of Science requirements of this department. Several 2000-level courses are available from NPS Continuing Education. The courses are self-study and can be used to help prepare the student for graduate work.

2. Approved Curriculum. The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, approved curriculum must satisfy the requirements in paragraphs 3 and 4.

3. Required Courses. The Master of Science degree in Mechanical Engineering requires at least 32 quarter hours of graduate level credits in Mechanical Engineering and Materials and Science, at least 10 of which must be at the 4000 level. In addition, at least 8 quarter hours of graduate credit must be earned outside of Mechanical Engineering and Materials Science.

4. Thesis. An acceptable thesis is required for the Master of Science in Mechanical Engineering degree. An acceptable thesis for the Mechanical Engineering degree may also be accepted as meeting the thesis requirement for the Master's degree. Approval of the thesis topic must be obtained from the Chairman of the Mechanical Engineering Department. An advisor will be appointed by the Chairman of the Mechanical Engineering Department for consultation in the development of a program of research.

## MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in mechanical engineering at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Mechanical Engineering Department. A total of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

## THE PROGRAM LEADING TO THE DEGREE OF MECHANICAL ENGINEER

A graduate student with a superior academic record may enter a program leading to the degree Mechanical Engineer. A candidate is normally selected during his second year of residence.

The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, approved curriculum must satisfy the requirements stated in paragraphs 3 and 4 below.

The Mechanical Engineer degree requires at least 60 quarter hours of graduate level credits in Mechanical Engineering and Materials Science, and in addition, at least 12 quarter hours of graduate level credits must be earned outside of Mechanical Engineering and Materials Science. At least 30 of the above required graduate level credits must be at the 4000 level.

An acceptable thesis is required for the Mechanical Engineer degree. Approval of the thesis program must be obtained from the Chairman of the Mechanical Engineering Department. An advisor will be appointed by the Chairman of the Mechanical Engineerng Department for consultation in the development of a program of study and a program of research.

## DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Mechanical Engineering has an active program leading to the degrees of Doctor of Philosophy and Doctor of Engineering. Areas of special strength in the department are viscous flows, shipboard automation, heat transfer, materials science applied to corrosion and armor, finite element analysis, laser technology, piping technology and hydrodynamics.

Joint programs with other departments are possible. A noteworthy feature of the program leading to the Doctor of Engineering degree is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the Federal Government. The degree requirements are as outlined in Section 250 of the Academic Council Policy Manual.

## MECHANICAL ENGINEERING LABORATORIES

The Mechanical Engineering Laboratories are designed as complements to the educational mission and research interests of the department. In addition to the extensive facilities for the support of student and faculty research, a variety of general use equipment is available. This includes machinery for the investigation of dynamic and static problems in engineering mechanics; a completely equipped materials science laboratory; a scanning electron microscope; a water tunnel, and a wave channel; facilities for experimentation with air flows from incompressible through supersonic velocities; equipment for instruction in thermal transport phenomena; a laboratory for demonstrating nuclear engineering principles; and a fluid power control and fluidics laboratory. Currently being developed are a shipboard automation laboratory and a nondestructive test, NDT, laboratory. Experimentation is further enhanced by a broad selection of analog and digital data acquisition and processing equipment and instrumentation.

### MECHANICAL ENGINEERING

**ME/MS 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

**ME 0951 Seminars (0-1).**
Lectures on subjects of current interest are presented by NPS faculty and invited experts from other universities and government and industrial activities.

*Lower Division Course*

**ME 1000 Preparation for Professional Engineers Registration (3-0).**
The course will cover the topics from the 8-hour Professional Examination given by State of California for Professional Engineer. Both Mechanical and Metallurgical branches of the PE examination will be covered. Discussion will involve applicable engineering techniques including design, analysis, appraisal, evaluation, planning, systems, development and/or technical studies. Electronic, hand-held calculator required.

*Upper Division Courses*

**ME 2101 Engineering Thermodynamics (4-1).**
A comprehensive coverage of the fundamental concepts of classical thermodynamics, with insight toward microscopic phenomena. The laws of thermodynamics. Equations of state. Thermodynamic properties of substances. Entropy, irreversibility and availability. Cycle analysis. Gas-vapor mixtures. Combustion and dissociation. PREREQUISITE: MA 1116. (May be taken through Continuing Education as minicourse sequence ME 2111-15.)*

**ME 2201 Introduction to Fluid Mechanics (3-2).**
Properties of fluids. Fluid statics, stability of submerged bodies. Mass, momentum, and energy considerations in steady flows. Dynamic similitude and dimensional analysis. Fluid measurement and control. Basic effects of fluid friction. Emphasis on naval engineering applications and problem solving. PREREQUISITE: ME 2502. (May be taken through Continuing Education as minicourse sequence ME 2211-14.)*

**ME 2410 Mechanical Engineering Lab I (2-3).**
Fundamentals of mechanical measurement systems, structured laboratory experiments using resistance strain gages, pressure transducers, temperature, flow and velocity measurement devices. PREREQUISITES: ME 2101, ME 2201, and ME 2601, any of which may be taken concurrently. Graded on Pass/Fail basis only.

**ME 2501 Statics (3-0).**
Forces and moments, particles and rigid bodies in equilibrium. Simple structures, friction, first moments and centroids. PREREQUISITE: MA 1116 (may be concurrent). (May be taken through Continuing Education as minicourse sequence ME 2511-13.)*

**ME 2502 Dynamics (4-0).**
Kinematics, Newton's laws and d'Alembert's principle work and energy, impulse and momentum, plane motion of a rigid body. PREREQUISITE: ME 2501.

**ME 2601 Mechanics of Solids I (3-2).**
Stress, strain, Hooke's law. Elementary stress and deformation analysis for shafts, beams and columns. Supporting laboratory work. PREREQUISITES: ME 2501, or ME 2510, and MA 1116.

**The minicourses are described in the Continuing Education catalog.*

*Upper Division or Graduate Courses*

**ME 3003 Energy and the Environment (3-0).**
Principles of energy technology. Supply and demand. Survey of resources including coal, oil, gas, and uranium fuels. Solar energy utilization. Energy conversion schemes. Conservation efforts in the Navy. Effect of energy utilization upon the environment. This is an elective course for non-M.E. majors.

**ME 3150 Heat Transfer (4-2).**
Elementary treatment of the principles of Heat Transfer application to problems in Mechanical Engineering. Steady and unsteady conduction. Principles of forced and natural convection. Thermal radiation. Boiling. Condensation. Heat exchanger analysis. Use of the thermal circuit analog numerical and graphical techniques. Selected laboratory experiments. PREREQUISITES: ME 2101, ME 2201, MA 3132 (may be taken concurrently).

**ME 3201 Applied Mechanics of Naval and Ocean Structures I (3-2).**
Equations of motion for surface and subsurface vessels. Path keeping and stability. Maneuvering. Ship resistance. Hydrodynamics of lifting surfaces. Selected topics. PREREQUISITE: ME 2201.

**ME 3250 Fluid Machinery (3-2).**
Fundamental characteristics of reciprocating power pumps, direct-acting steam pumps, pump valves, rotary pumps, pistonless pumps, centrifugal and axial pumps, air compressors and compressor accessories, turbomachines, and centrifugal and axial fans. Efficiency of fluid machinery. Application to practical fluid-handling systems and naval operations of pumps, compressors, fans, and turbomachinery. Installation, operation, and maintenance of fluid machinery. PREREQUISITES: ME 2101 and ME 2201.

**ME 3301 Nuclear Power Systems (5-0).**
Brief review of atomic, nuclear structures, and nuclear reactions. Neutron interactions with matter: cross sections, slowing down and diffusion of neutrons. Fundamentals of nuclear reactor analysis: neutronic and thermal aspects in core design. Principal reactor types. Naval applications of nuclear energy.

**ME 3315 Nuclear Measurements Lab (1-4).**
Principles of radiation detection. The use of various health physics instruments and radiation detectors; gas-filled, scintillation, crystal and foil detectors; calibration of detectors. Experiments in neutron physics: determination of neutron Fermi age and diffusion length. Neutron fast and thermal fluxes mapping by various detectors. Determination of flux perturbation by local absorption. Gamma ray spectrometry; pulse height analyzer. PREREQUISITES: ME 2410, ME 3301 or equivalent, ME 3341.

ME 3430 Mechanical Engineering Lab II (1-3).
A project-oriented continuation of mechanical measurement systems. Application of measurement techniques using group projects in thermodynamics, mechanics of solids, heat transfer, fluid flow, vibrations and nuclear radiation detection. PREREQUISITES: ME 2410, ME 3150, ME 3521, and ME 3611. Graded on Pass/Fail basis only.

ME 3440 Engineering Systems Analysis (4-0).
Classification of engineering problems. Classical and numerical techniques for solving equilibrium, eigenvalue, and propagation problems for discrete and continuous systems. Applications to heat transfer fluids, and solids problems. PREREQUISITES: ME 2101, ME 2201, ME 3521, and ME 3611.

ME 3450 Thermodynamics of Marine Power Systems (3-2).
Current applications of thermodynamic principles applied to marine power systems. Detailed analyses of vapor and gas power cycles. The characteristics of engines, compressors, and turbines. Refrigeration, air conditioning and cryogenic systems. PREREQUISITE: ME 2101.

ME 3521 Mechanical Vibration (3-2).
Free and forced vibration of discrete linear systems. Vibration isolation and suppression. Vibration of bars, shafts, and beams. Supporting laboratory work. PREREQUISITES: ME 2502, or ME 2510, ME 2601, and MA 2401 (may be concurrent).

ME 3611 Mechanics of Solids II (4-0).
Constitutive laws for linear elastic solids. Fundamentals of the theory of elasticity. Applications to beams. Stability of simple structures. Torsion of members with non-circular cross section. Elements of plate and shell behavior. PREREQUISITES: ME 2502, or ME 2510, ME 2601, and MA 2401 (may be concurrent).

ME 3711 Design of Machine Elements (3-2).
The design of representative machine elements with consideration given to materials, tolerances, variable loads and stress concentrations. PREREQUISITE: ME 3611.

ME 3801 Fluid Power Control (3-2).
Operation and analysis of control valves and actuators. Hydraulic power elements. Steady state and dynamic performance of electro-hydraulic servovalves and servomechanisms. Design criteria for fluid power controls. PREREQUISITE: ME 2201 (may be taken concurrently).

*Graduate Courses*

ME 4160 Applications of Heat Transfer (4-0).
Application to heat transfer principles to engineering systems. Topics include heat exchanger (e.g., boilers, condensers, coolers), cooling electronic components, heat pipes, solar collectors, turbine blade cooling. PREREQUISITE: ME 3150.

ME 4161 Conduction and Radiation Heat Transfer (4-0).
Steady-state heat conduction in multi-dimensions with and without heat sources. Transient conduction. Numerical methods for heat conduction. Variational methods. Mechanical Engineering applications. Black body radiation; radiation from real surfaces; radiation exchange between finite surfaces. The network method, radiation through participating media. PREREQUISITE: ME 3150.

ME 4162 Convection Heat Transfer (4-0).
Fundamental principles of forced and free convection. Dimensionless correlations. Heat transfer during phase changes. Combined conduction, convection and radiation heat transfer systems. Heat exchanger analysis with Mechanical Engineering applications. PREREQUISITES: ME 3150, ME 4220 (may be taken concurrently).

ME 4211 Naval Hydrodynamics (4-0).
Equations of motion. Vorticity and circulation. Solutions to flow about two- and three-dimensional bodies. Conformal transformations and hydrofoils. Approximate methods of flow analysis. Free surface hydrodynamics with Naval Engineering applications. PREREQUISITE: ME 3201, or consent of Instructor.

ME 4220 Viscous Flow (4-0).
Development of continuity and Navier-Stokes equations. Exact solutions of steady and unsteady viscous flow problems. Low

Reynolds number flows. Development of the boundary layer equations. Similarity variables, numerical and integral techniques. Separation, boundary layer control, compressibility effects. Time-dependent boundary layers. Stability, transition, and turbulence. Nature of turbulence, phenomenological theories, calculation of turbulent flows. PREREQUISITES: ME 2101 and ME 2201.

**ME 4230 Advanced Topics in Fluid Dynamics and Heat Transfer (4-0).**
Topics selected in accordance with the research interests of students and staff. Advanced and analytical methods. Surveys of current Mechanical Engineering technologies. Extensions to the theories of fluid flow and heat transfer. PREREQUISITES: ME 4161, ME 4162, and MA 2172 (may be taken concurrently), or consent of Instructor.

**ME 4240 Applied Mechanics of Naval and Ocean Structures II (3-2).**
Nonlinear surface waves and fluid-structure interactions. Free-streamline analysis of cavities, planing, and gliding. Hydro-ballistics, water-exit and entry studies. Quiet torpedo technology. Topics selected in accordance with the current interests of the students and the Navy. PREREQUISITES: ME 3201, ME 4211, and ME 4220.

**ME 4311-ME 4312 Nuclear Reactor Analysis I-II (4-0).**
Neutron cross-sections. Resonance phenomena and Doppler effect. The fission process. The slowing down and diffusion of neutrons. Criticality analysis of homogenous and heterogeneous reactors. Reflected reactors. Multigroup diffusion method. Fundamentals of neutron transport theory. Reactor kinetics and control. Change in reactivity during reactor lifetime. Application of perturbation theory to reactivity calculations. PREREQUISITE: ME 3301 or equivalent.

**ME 4321 Reactor Engineering Principles and Design (4-2).**
Reactor heat generation and removal. Thermal stress analysis. Nuclear fuel cycle. Change in reactivity during core lifetime. Overriding of fission product poisoning. Principal types of reactor systems. The synthesis of reactor physics, heat transfer and hydraulics, properties of materials and safety requirements in reactor design. Student group design project. PREREQUISITES: ME 3301 and ME 3150.

**ME 4410 Marine Gas Turbines (3-2).**
Thermodynamic analyses of gas turbine cycle variations (e.g., simple, regenerated, combined). Internal aerodynamics of compressor and turbine design. Combustor design. Lubrication and fuel systems. Operational control and instrumentation. Inlet, exhaust, and silencing systems. Repair and maintenance. Propulsion of hydrofoil, surface effect, and conventional surface ships. Auxiliary power generation. Waste heat utilization. Naval research and development. PREREQUISITE: ME 3450 or consent of Instructor.

**ME 4504 Naval Weapons I: Guns, Mines and Torpedoes (4-0).**
Gun internal ballistics; gun propellant combustion, one-dimensional unsteady model of gas flow. External ballistics: flat-earth trajectory equations with aerodynamic forces and/or propulsion. Guided projectiles. Fire control. Damage by blast in air and water. Mines; sensors and firing logic; mine detection and neutralization. Torpedoes: hydrodynamic drag, propulsion, warheads. PREREQUISITE: Consent of Instructor.

**ME 4505 Naval Weapons II: Laser Technology (4-0).**
Types of lasers according to pumping mechanisms, laser performance, propagation of laser beams, pointing and tracking, acquisition and handoff, damage mechanisms, advantages and limitations of high energy lasers and military applications. PREREQUISITE: Consent of Instructor. (May also be taught as AE 4505).

**ME 4506 Naval Weapons III: Missile Engineering (4-0).**
Aim of course is to provide a technical overview of shipboard based tactical missiles and submarine based strategic missiles, ICBM and cruise missiles. Missile trajectories. Propulsion; rocket, ramjet, and ordnance turbojets. Missile aerodynamics. Guidance and control. Reentry phenomena. Missile design features; mission range, lethality, maneuverability, Mach number and payload. Missile examples: AEGIS, Poseidon, Trident, MX. PREREQUISITE: Consent of Instructor.

**ME 4507 Naval Weapons IV: Weapons Systems Integration (4-0).**
The aim of the course is to highlight the various limitations and constraints imposed on a weapons suite by interface with the platform. Weapon-platform interfaces and constraints include utilities weight, volume, location, environmental factors and platform motion. Target data acquisition and processing; interaction of several weapon suites. PREREQUISITE: Consent of Instructor.

**ME 4512 Advanced Dynamics (4-0).**
Three-dimensional kinematics. The inertia tensor. Dyadic-vector formulation of dynamical equations. Topics of special interest. PREREQUISITE: ME 3521.

**ME 4522 Vibration, Noise, and Shock (4-0).**
Matrix analysis of many degree of freedom systems. Discrete models of continuous systems. Transfer matrices. Applications to shipboard vibration and noise control. Shock response analysis. PREREQUISITE: ME 3521.

**ME 4612 Advanced Mechanics of Solids (4-0).**
Additional advanced topics. PREREQUISITES: MA 3132 or equivalent and ME 3611.

**ME 4613 Finite Element Methods (4-0).**
Systematic construction of line, surface, and volume elements for continuous systems. Applications to structural mechanics, heat transfer, fluid flow. PREREQUISITE: ME 3611.

**ME 4620 Theory of Continuous Media (4-0).**
Tensor analysis. Stress and strain tensors. Motion of a continuum. Energy and entropy. Constitutive equations. Applications to elasticity and fluid dynamics. PREREQUISITES: ME 2201, ME 3611, and MA 2401.

**ME 4721 Marine Vehicle Design I (2-4).**
Various categories of marine vehicles are described; this includes single hull, multiple hull, submarine, surface effect, wing-in-ground effect and hydrofoil vehicles. A category of marine vehicle is selected to fulfill a stated mission. A vehicle configuration and specification of major components which satisfies mission requirements is sought. Consideration is given to all major facets of marine vehicle synthesis including structures, hull forces, propulsion, electronics, armament, crew, etc. PREREQUISITE: Consent of Instructor.

**ME 4722 Marine Engineering Design (2-4).**
A major component of a marine vehicle is designed so as to meet stated specifications. Impact of the design features of the major component upon the overall vehicle performance is considered; emphasis is on design tradeoffs. Examples of major components to be designed include complete electrical power generation and distribution system, steering, superconducting electrical motors for main propulsion, bulbous bow for sonar, armor protection of CIC, etc. PREREQUISITE: Consent of Instructor.

**ME 4802 Marine Propulsion Control Systems (3-2).**
Fundamental characteristics of electro-pneumatic and electro-pneumatic and electro-hydraulic control systems operational in both steam turbine and gas turbine powered ships. Systems analysis — controllability and stability. System design using model techniques. PREREQUISITE: Consent of Instructor.

**ME 4902 Advanced Study in Mechanical Engineering (2-0 to 6-0).**
Directed advanced study in mechanical engineering on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman. Graded on Pass/Fail basis only.

## MATERIALS

*Upper Division Course*

**MS 2201 Engineering Materials (3-2).**
Fundamental principles of materials science are presented with particular emphasis on mechanical behavior. The effects of atomic structure, crystal structure, and microstructure on properties of structural materials are emphasized. Crystalline defects, deformation processes, strengthening mechanisms, brittle fracture, phase equilibria, heat treatment, and microstructural control are discussed with reference to practical examples. The course aims at providing the

Naval Engineering student with the vocabulary and conceptual understanding necessary for further study or for communicating with materials experts. PREREQUISITE: Elementary courses in physics and chemistry.

*Upper Division or Graduate Courses*

**MS 3201 Materials Science and Engineering (3-2).**
Intended as a first course in materials for students who have had an undergraduate survey course in materials (such as MS 2201), or who have a good background in chemistry, thermodynamics, and physics. Fundamental principles of materials science are presented with particular emphasis on mechanical behavior. Topics covered include atomic structure, crystal structure, microstructure, crystalline defects, deformation processes, strengthening mechanisms, fracture, and phase transformations. PREREQUISITE: Undergraduate course in materials, and/or courses in chemistry, thermodynamics, and physics.

**MS 3202 Properties, Problems, and Failures of Structural Materials (3-2).**
Topics of interest to the Naval, Aero, or Weapons engineer are emphasized through case studies of actual failures. The cause(s) of each failure are presented, and the necessary background material to fully understand the phenomena is then provided in each case. Failures due to fatigue, brittle fracture, corrosion, and fabrication deficiencies are among those discussed. Selection of materials and modern methods of materials analysis are treated. PREREQUISITE: MS 2201 or equivalent, or permission of Instructor.

**MS 3206 Imperfections in Crystalline Solids (3-0).**
The effects of crystalline defects on the physical and mechanical behavior of solids are discussed. This course examines in moderate detail those microstructural features which have a major impact on materials development, fabrication, and utilization. Example topics are point defects in electronics, materials, strain-aging phenomena, the role of stacking faults in material failure, and subgrain strengthening. PREREQUISITE: MS 2201 or equivalent.

**MS 3304 Corrosion (3-2).**
Presents the basic chemical, electrochemical, mechanical, and metallurgical factors which influence the corrosion, oxidation, and deterioration of materials. Discusses standard methods of corrosion control, such as cathodic protection coatings, cladding, alloy selection, and inhibitors; special problems encountered in unfamiliar environment. PREREQUISITE: MS 2201 or equivalent.

**MS 3305 Materials for Electrical and Electronic Applications (3-0).**
The materials used in electrical and electronic applications are discussed, including ferromagnetic and ferri-magnetic materials, semiconductors, insulators, dielectrics, and piezoelectric and ferroelectric crystals. The electronic, crystallographic and thermodynamic principles controlling these materials are discussed and the heat treatments, compositions, and methods of fabrication of commercial materials are emphasized. PREREQUISITE: Consent of Instructor.

**MS 3401 Microscoopy (3-2).**
Electron microscopy and other sophisticated techniques are emphasized in a coverage of modern methods of microscopic observation. Techniques covered include scanning electron microscopy, transmission electron microscopy, conventional microprobe analysis, field ion microscopy, and polarized light, stereo, interference, phase contrast, and holographic light optical methods. Course and lab will simultaneously cover both theory and practice, including specimen preparation, instrument design and operation, and applications. PREREQUISITE: Consent of Instructor.

**MS 3505 Materials Selection for Military Applications (4-0).**
This course deals in depth with one of the most common and important problems in materials engineering, that of selecting the optimum material for a given application. Consideration is also given to evolution of new applications for existing materials, and to materials development for new and old applications. A variety of application areas are covered, including marine structures, aerospace applications, nuclear reactors, electronics, high temperature cryogenic services, and many other situations. Sources of infor-

mation, methodology, and basic rationale for materials selection decisions are presented. Emphasis is put on the variation in properties of a given material with processing history, and on variation of properties in service. PREREQUISITE: MS 2201 or equivalent.

*Graduate Courses*

**MS 4215 Phase Transformation (3-2).**
Structural changes which commonly occur in materials by various mechanisms are considered. Solidification, precipitation, recrystallization, and martensitic transformations are emphasized, both in principle and in regard to their technological importance. Principles of nucleation and growth, diffusion and kinetics are presented and their relevance to practical heat treating and fabrication processes are considered. PREREQUISITE: MS 2201 or equivalent.

**MS 4302 Special Topics in Materials Science (Hours by arrangement).**
Independent study of advanced subjects not regularly offered. PREREQUISITE: Consent of Instructor.

**MS 4312 Advanced Materials (4-0).**
The course is structured to provide a vehicle for the study of materials pertinent to a specific area of environment utilization or design. Example categories are marine materials, nuclear materials, elevated-temperature materials, aircraft alloys, materials for energy conversion. Topics discussed may include material failures, materials selection, testing, and new concepts in materials engineering. Course scope is decided by mutual agreement of students and Instructor. PREREQUISITE: MS 2201, MS 3202, or equivalent.

**MS 4811 Mechanical Behavior of Engineering Materials (3-2).**
The response of structural materials to mechanical stress is discussed with emphasis on plastic deformation in metals. Topics include mechanisms of high-temperature deformation, fatigue, and fracture. New concepts allowing development of materials to circumvent these failure mechanisms are treated. PREREQUISITES: MS 3202 or permission of Instructor.

# DEPARTMENT OF METEOROLOGY

*Air-Ocean Science students with the FNWC prototype of the Naval Environmental Display Station (NEDS).*

**George Joseph Haltiner,** Distinguished Professor of Meteorology; Chairman (1946)*; B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

**Chih-Pei Chang,** Associate Professor of Meteorology (1972); B.S., National Taiwan Univ., 1966; Ph.D., Univ. of Washington, 1972.

**Kenneth La Vern Davidson,** Associate Professor of Meteorology (1970); B.S., Univ. of Minnesota, 1962; M.S., Univ. of Michigan, 1966; Ph.D., 1970.

**Russell Leonard Elsberry,** Associate Professor of Meteorology (1968); B.S., Colorado State Univ., 1963; Ph.D., 1968.

**Robert Lee Haney,** Associate Professor of Meteorology (1970); A.B., George Washington Univ., 1964; Ph.D., Univ. of California at Los Angeles, 1971.

**Robert Joseph Renard,** Professor of Meteorology (1952); M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

**Willem van der Bijl,** Associate Professor of Meteorology (1961); B.Sc., Free Univ. of Amsterdam, 1941; M.Sc., 1943; Ph.D., State Univ. Utrecht, 1952.

**Forrest Roger Williams, CDR,** U.S. Navy; Assistant Professor of Meteorology (1974); B.S., Naval Academy, 1956; M.S., Naval Postgraduate School, 1962; M.S., Massachusetts Institute of Technology, 1972.

**Roger Terry Williams,** Professor of Meteorology (1968); A.B., Univ. of California at Los Angeles, 1959; M.A., 1961; Ph.D., 1963.

## EMERITUS FACULTY

**William Dwight Duthie,** Distinguished Professor Emeritus (1945); B.A., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

**Frank Lionel Martin,** Professor Emeritus (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

## VISITING FACULTY

**Richard Allen Anthes,** Visiting Professor of Meteorology (1977); B.S., Univ. of Wisconsin, 1966; M.S., 1967; Ph.D., 1970.

**Hans Peter Gemein,** Visiting Assistant Professor of Meteorology (1977); Dipl.-Phys., Univ. of Bonn, 1973, German Military Geophysical Office (GMGO).

**Ka-Ming William Lau,** Adjunct Assistant Professor of Meteorology (1977); B.S., Univ. of Hong Kong, 1972; M.S., Univ. of Washington, 1974; Ph.D., 1977.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## DEPARTMENT REQUIREMENTS FOR DEGREES IN METEOROLOGY OR METEOROLOGY AND OCEANOGRAPHY

### MASTER OF SCIENCE IN METEOROLOGY

1. Entrance to a program leading to a Master of Science degree in Meteorology requires mathematics through differential and integral calculus and a minimum of one year of college physics.

2. The degree of Master of Science in Meteorology requires completion of:

a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of partial differential equations.
b. Thirty-five quarter hours of graduate meteorology courses of which 15 hours must be in the 4000 series.
c. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology, must be included in these 35 hours.
d. An acceptable thesis.

### MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. Direct entrance to a program leading to the degree Master of Science in Meteorology and Oceanography requires a baccalaureate degree in meteorology and/or oceanography or equivalent. This normally permits the validation of required undergraduate courses such as physics, chemistry, differential equations, linear algebra, vector analysis and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event the program may be lengthened by one or two quarters.

**Indirect** entry into the program is possible for persons lacking a baccalaureate degree in meteorology or oceanography through the oceanography curriculum (440). Minimal entrance requirements here include differential and integral calculus, and a year each of college physics and chemistry.

2. The degree of Master of Science in Meteorology and Oceanography requires:

a. Completion of 48 quarter hours of graduate courses in meteorology and oceanography including MR/OC 4413, MR 4322, MR 4323 and 10 quarter hours in the 4000 oceanography series. The degree program must be approved by both the Department of Meteorology and the Department of Oceanography.

b. Completion of an acceptable thesis on a topic approved by either department.

## DOCTOR OF PHILOSOPHY

The Ph.D. is offered in the Department of Meteorology in the following areas of study: numerical weather prediction, geophysical fluid dynamics, analysis of atmospheric systems, and tropical meteorology.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation, examination in both the major and a minor field, and languages. The minor field is usually in oceanography, mathematics or physics.

The required examinations are described in this catalog in the section Requirements for the Doctor's Degree. The Department of Meteorology also requires a preliminary examination in order to show evidence of acceptability as a doctoral student.

Prospective students should consult with the Chairman of the Department of Meteorology for further information and guidance regarding doctoral programs.

## METEOROLOGICAL LABORATORIES

In addition to the standard synoptic laboratories, NPS meteorological facilities include most instruments in present-day use for observing the atmosphere as well as equipment for copying weather data, analyses and forecasts emanating from the National Weather Service. Similar information is received from Fleet Numerical Weather Central in Monterey. The Naval Environment Display Station is scheduled to be installed by FY 1979. Rawinsonde and wiresonde equipment, an acoustic sounder, an APT receiver for readout of weather satellite data and micrometeorologically instrumented masts on the Research Vessel ACANIA are utilized by faculty and students in the Meteorology and Oceanography Programs.

## METEOROLOGY

**MR 0110-11-12 Applications Seminars (1-0).**
Presentation of DOD related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students and visiting authorities. MR 0110 is for orientation; MR 0111 is for beginning students; MR 0112 is for advanced students. PREREQUISITE: Enrollment in an Environmental Sciences curriculum.

**MR 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

**MR 0999 Seminar in Meteorology (2-0).**
Students present results of thesis or other approved research investigation. PREREQUISITE: Concurrent preparation of thesis or other acceptable research paper.

*Upper Division Courses*

**MR 2200 Introduction to Meteorology (4-0).**
An introduction course that treats the composition and structure of the atmosphere, thermodynamic processes, forces and related small- and large-scale motions, air masses,

fronts, severe storms, solar and terrestrial radiation, general circulations and weather forecasting. PREREQUISITE: Department approval. (May be taken through Continuing Education as the minicourse sequence MR 2201-02.)*

**MR 2210 Introduction to Meteorology/Laboratory (4-3).**
Same course as MR 2200 but with laboratory periods illustrating lecture material including weather map analysis over oceanic areas using satellite images. PREREQUISITE: Department approval.

**MR 2413 Meteorology for Antisubmarine Warfare (3-0).**
A general course in meteorology for the ASW curriculum. Atmospheric stability and EM wave propagation are related to vertical distributions of temperature and moisture; precipitation, clouds and wind are related to synoptic systems; boundary fluxes are related to momentum exchange from the free atmosphere; changes in the mixed layer depth are related to boundary fluxes. PREREQUISITES: Differential and integral calculus.

**MR 2416 Meteorology for Electronic Warfare (2-0).**
A survey of environment factors affecting the propagation and attenuation of electromagnetic (EM) and optical (EO) waves in the atmosphere; vertical distributions of temperature and moisture in standard atmosphere; synoptic conditions associated with anomalous propagation of electromagnetic waves; regions and layers associated with high level turbulence intensities affecting optical wave propagation; climatologies of high altitude ionized regions affecting propagation of EM waves greater than 10 meter wavelength. PREREQUISITES: MA 3139 or PS 3411.

**The minicourses are described in the Continuing Education catalog.*

**MR 2520 Climatology and Statistics (3-1).**
Discussion of climate classifications, changes and controls. Climates of areas important to the Navy. Basic statistical quantities (mean, standard deviation, correlation and regression) are introduced and their role in climatology demonstrated. PREREQUISITE: MR 2200 or MR 2210.

*Upper Division or Graduate Courses*

**MR 3150 Geophysical Random Processes (3-1).**
Estimation and decision theory. Spatial and temporal sampling of geophysical data. Harmonic analysis and orthogonal functions. Time series analysis. PREREQUISITE: MR 2520.

**MR 3212 Polar Meteorology/Oceanography (3-1).**
Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea-ice; its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions, aspects of geology and geophysics. PREREQUISITES: MR 3230, OC 3221.

**MR 3220 Meteorological Analysis (4-0).**
Techniques of evaluation, interpretation and analysis of pressure, wind, temperature and moisture data, including weather satellite observations, with emphasis on the low and middle troposphere. Synoptic models of extratropical vortices, waves and frontal systems, with emphasis on three dimensional space structure and time continuity. Introduction to analysis in the high troposphere and low stratosphere. PREREQUISITES: MR 2210 or equivalent; MR 3321 or OC 4321, or consent of the Instructor.

**MR 3225 Meteorological Analysis Laboratory (0-4).**
Applications of concepts considered in MR 3220 with emphasis on the analysis of the low and middle troposphere, especially surface and 500 mb charts and associated vertical cross sections. PREREQUISITES: MR 3220 concurrently; MR 2210 or equivalent.

**MR 3230 Tropospheric and Stratospheric Meteorology (4-0).**
An analytic and synoptic interpretation of tropospheric and stratospheric systems with emphasis on the middle and high altitude aspects of extratropical cyclones, jet streams and fronts, and related dynamical properties. PREREQUISITES: MR 3220, MR 4322 concurrently.

**MR 3235 Tropospheric and Stratospheric**

Meteorology Laboratory (0-8).
Practice in synoptic-scale analysis of parameters considered in MR 3230 with emphasis on objectivity, interrelationships and application to forecast problems. PREREQUISITES: MR 3225, MR 3230 concurrently.

MR 3240 Operational Environmental Products (0-4).
Meteorological and oceanographical products available to the operating fleet from Fleet Numerical Weather Central/Fleet Weather Centrals and other sources are described and applied to the diagnosis and prognosis of tactical environmental parameters for both current and historical situations. PREREQUISITES: MR 2210 and OC 3221.

MR 3250 Tropical Meteorology (3-0).
Structure and development of tropical cyclones; observations of synoptic-scale wave disturbances, cloud clusters, upper tropospheric systems, the intertropical convergence zone and monsoon circulations; tropical scale analysis and energetics. PREREQUISITES: MR 4322, MR 3220.

MR 3252 Tropical Meteorology/Laboratory (3-4).
Same as MR 3240 plus laboratory sessions on streamline, isotach and contour (isobaric) analyses and forecasting of tropical systems, with emphasis on tropical cyclones and the use of meteorological satellite observations. PREREQUISITES: MR 3220/5 and MR 4322.

MR 3260 Prognostic Charts and Forecasting Weather Elements (3-0).
Subjective and objective methods of atmospheric prognosis and techniques for forecasting operationally-important weather elements from surface to 10 mb. Interpretation, use and systematic errors of computer-generated products. PREREQUISITES: MR 3230; MR 4323 or consent of Instructor.

MR 3262 Prognostic Charts and Forecasting Weather Elements/Laboratory (3-4).
Same as MR 3260 plus laboratory sessions on the application of lecture material. Also practice in weather briefing, including diagnosis and forecasting of current weather situations using weather satellite observations and National Meteorological Center and Fleet Numerical Weather Central products. PREREQUISITES: MR 3230, MR 4323 or consent of Instructor.

MR 3321 Air-Ocean Fluid Dynamics (4-0).
The hydrodynamical equations for a rotating fluid. Forces, kinematics, simple balanced flows, barotropy, baroclinicity, vertical shear; various vertical coordinates. Friction and boundary layers, introduction to scale analysis. Vorticity and divergence equations. PREREQUISITES: MA 2048, MA 2121 (may be concurrent), or equivalent.

MR 3420 Geophysical Thermodynamics (4-0).
The physical variables; properties of gases, water and moist air; equations of state and the laws of thermodynamics applied to the atmosphere and oceans, entropy, adiabatic processes and potential temperatures; meteorological thermodynamic diagrams; geopotential and hydrostatic equilibrium, static stability criteria and phenomena. PREREQUISITES: Calculus, MR 2200 or equivalent, or consent of Instructor.

MR 3421 Cloud Physics (3-0).
Basic principles of cloud and precipitation physics and application to weather modification. Selected topics in atmospheric pollution. PREREQUISITE: MR 3420.

MR 3512 Heat Transfer Processes (4-0).
Monochromatic intensity and flux from black bodies; other properties of black bodies. The flux of terrestrial radiation crossing an arbitrary level in an atmosphere consisting both of water vapor and carbon dioxide. Terrestrial flux-divergence as a cooling effect in the atmosphere. Solar insolation at the outer boundary of the atmosphere and at the earth; parameterization of solar attenuation processes in the atmosphere. The mean heat balance of the earth and atmosphere. Net radiative energy as a driving mechanism for the general circulation. PREREQUISITE: MR 3420 or consent of Instructor.

*Graduate Courses*

MR 4241 Mesoscale Meteorology (3-0).
Descriptive and physical understanding of subsynoptic scale weather systems and their relation to the synoptic-scale environment. Applications to short-range and local-area forecasting

utilizing satellite and numerical-model products relevant to mesoscale weather phenomena. PREREQUISITES: MR 3230/5; MR 4323, or MR 4322 with consent of Instructor.

MR 4242 Advanced Tropical Meteorology (3-0).
Equatorial wave theory; stratospheric wave motions and quasi-biennial oscillations; tropospheric disturbances; energy sources and instabilities; boundary layer and cumulus convection parameterization; monsoon circulations and their interactions with other scales; and selected topics in dynamics and thermodynamics of tropical flows. PREREQUISITE: Consent of Instructor.

MR 4250 General Circulation of the Atmosphere and Oceans (3-0).
Selected topics on the general circulation of the atmosphere (e.g., heat, momentum and moisture fluxes; energetics) and ocean (e.g., linear and nonlinear theories of the wind-driven ocean circulation, nonlinear thermocline theories, mesoscale eddies, mixed-layer theories), coupled ocean-atmosphere general circulation models. PREREQUISITE: Consent of Instructor.

MR 4322 Dynamic Meteorology (4-0).
Scale analysis, perturbation method; solutions of equations of motion for sound, gravity, and synoptic waves, filtering; baroclinic and barotropic instability; geostrophic adjustment. PREREQUISITE: MR 3420, MR 3321, MA 3132 or equivalent.

MR 4323 Numerical Air and Ocean Modeling (4-3).
Numerical models of meteorological and oceanographic phenomena. Finite difference techniques for solving elliptic and hyperbolic equations, linear and nonlinear computational instability. Filtered and primitive equation prediction models. Energetics. Sigma coordinate. Objective analysis, initialization and four-dimensional data assimilation as time permits. PREREQUISITES: MR 4322, MA 3232.

MR 4324 Advanced Numerical Weather Prediction (3-0).
Initialization, boundary conditions, finite-difference schemes, stability and convergence; sensible, latent, and radiative heat transfer, simulation of sub-grid scale processes such as convection and friction; general circulation models, spectral methods. PREREQUISITES: MR 4323 or consent of Instructor.

MR 4331 Advanced Geophysical Fluid Dynamics I (3-0).
Advanced topics in the dynamics of the atmosphere and the oceans including scale analysis; geostrophic adjustment; dispersion, and barotropic and baroclinic instabilities. PREREQUISITE: Consent of Instructor.

MR 4332 Advanced Geophysical Fluid Dynamics II (3-0).
Energetics of unstable disturbances; energy cascade; boundary layer analysis with application to the Ekman layer and to the frictional and the nonlinear ocean boundary currents; finite amplitude effects. PREREQUISITE: Consent of Instructor.

MR 4413 Air/Sea Interaction (4-0).
Consequences of momentum, heat and moisture exchange between the atmosphere and the ocean. Concepts in turbulence and similarity theory for stationary turbulent regimes in the airflow over the sea. Dynamics of the oceanic well-mixed layer, large scale air sea interaction studies. PREREQUISITE: MR 4322 or consent of Instructor.

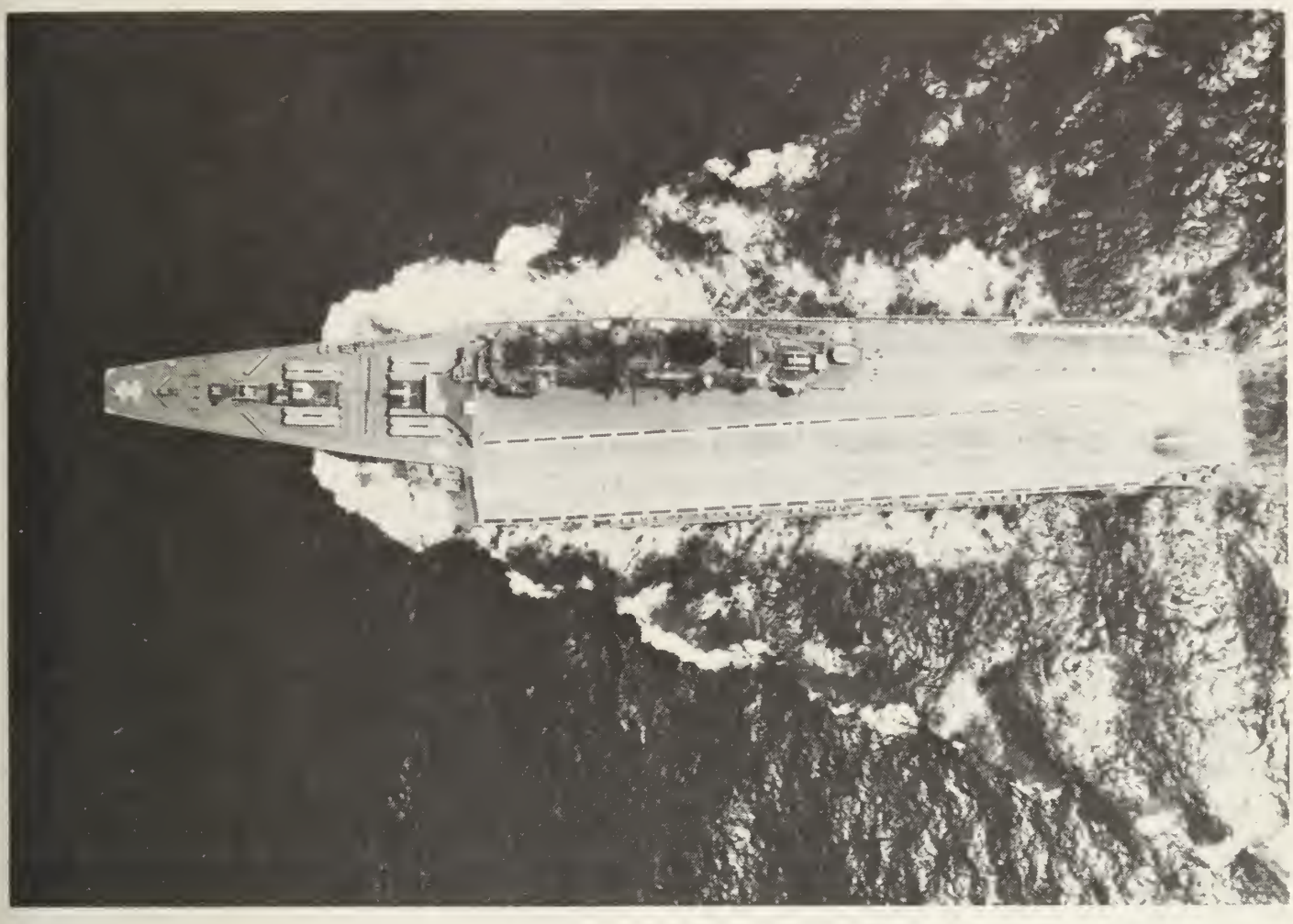
MR 4415 Atmospheric Turbulence (3-0).
Approaches for defining the structure of the turbulent atmospheric boundary layer. Review of statistical descriptions of atmospheric turbulence; averaging, moments, joint moments, spectral representation. Equations for a turbulent regime in a stratified, shear flow. Scaling parameters and similarity theories for surface layer profiles, spectra; Kolmogorov hypotheses, Monin-Obukhov stability length. Measurement of atmospheric turbulence. Examination of observed spectra and scales of atmospheric turbulence. PREREQUISITES: MR 4322 and MR 3150, or consent of Instructor.

MR 4416 Atmospheric Factors in Electromagnetic Propagation (3-0).
Principles of radar, laser and sound propagation in the atmosphere. Sensing from satellites, effects of atmosphere on propagation; refraction, scattering, attenuation, superrefraction, ducting, etc. Detection of atmospheric phenomena. PREREQUISITES: MR 3230; MR 3512, or consent of Instructor.

**MR 4800 Advanced Analysis and Prediction (3-0).**
Selected topics in geophysical fluid dynamics, advanced diagnostic and prognostic techniques including modeling, remote sensing, etc. The course may be repeated for credit as topics change. PREREQUISTE: Consent of Department Chairman.

*Interior area of research vessel ACANIA.*

# DEPARTMENT OF NATIONAL SECURITY AFFAIRS



*Students analyze Soviet naval exercises; the KIEV above is the Soviet's most modern aircraft carrier.*

**Patrick Johnston Parker,** Professor of Economics; Chairman (1974)*; M.B.A., Univ. of Chicago, 1955.

**John William Amos, II,** Assistant Professor of Political Science (1970); B.A., Occidental College, 1957; M.A., Univ. of California at Berkeley, 1962; Ph.D., 1972.

**David Patrick Burke,** Lt. Col., USAF, Assistant Professor of Political Science (1976); A.B., Univ. of California at Berkeley, 1956; M.A., San Francisco State College, 1963; M.P.A., Harvard Univ., 1969; Ph.D., 1975.

**Claude Albert Buss,** Professor of Political Science and History (1976); B.A., Washington Missionary College, 1922; M.A., Susquehanna Univ., 1924; Ph.D., Univ. of Pennsylvania, 1927.

**Donald Charles Daniel,** Assistant Professor of Political Science (1975); A.B., Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

**Boyd Francis Huff,** Professor of Government and History (1958); B.A., Univ. of Washington, 1938; M.A., Brown Univ., 1941; Ph.D., Univ. of California at Berkeley, 1955.

**Stephen Jurika, Jr.,** Adjunct Professor of Political Science (1975); B.S., U.S. Naval Academy, 1933; M.A., George Washington Univ., 1957; Ph.D., Stanford Univ., 1962.

**Edward John Laurance,** Associate Professor of Political Science (1972); B.S., U.S. Military Academy, 1960; M.A., Temple Univ., 1970; Ph.D., Univ. of Pennsylvania, 1973.

**Ralph Harry Magnus,** Assistant Professor of National Security Affairs (1976); A.B., Univ. of California at Berkeley, 1958; M.A., 1966; Ph.D., 1971.

**William Reese,** Professor of National Security Affairs and Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

**Barry Meir Schutz,** Assistant Professor of National Security Affairs (1977); A.B., Indiana Univ., 1960; M.A., Univ. of Calif. at Los Angeles, 1965; Ph.D., 1972.

**Ronald Graham Sherwin,** Assistant Professor of Political Science (1975); B.A., California State Univ. at Long Beach, 1965; M.A., Univ. of Southern California, 1967; Ph.D., 1972.

**Kamil Taha Said,** Associate Professor of National Security Affairs (1975); B.A., Colorado State College, 1937; M.A., San Jose State College, 1967.

**Russel Henry Stolfi,** Associate Professor of History (1966); B.S., Stanford Univ., 1954; M.A., 1964; Ph.D., 1966.

**Frank Michael Teti,** Associate Professor of Political Science (1966); B.A., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; M.P.A., Syracuse Univ., 1972; Ph.D., 1966.

**Jiri Valenta,** Assistant Professor of National Security Affairs (1976); Ing. Pol. Ek., Prague School of Economics, 1968; Ph.D., John Hopkins Univ., 1975.

**Peter Cheng-Chao Wang,** Associate Professor of Mathematics and National Security Affairs (1970); B.A., Pacific Lutheran Univ., 1961; M.A., Wayne State Univ., 1962; Ph.D., 1966.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## DEPARTMENTAL REQUIREMENTS FOR THE DEGREE MASTER OF ARTS IN NATIONAL SECURITY AFFAIRS

1. The entrance requirements for these programs are a baccalaureate degree earned with above average academic performance. Applicants must demonstrate their aptitude for the specific curriculum option concerned, through either the Graduate Record Examination or the completion of undergraduate courses which meet the prerequisite requirements for the courses offered in the option. Such applicants must have the approval of the Chairman, Department of National Security Affairs.

2. Degree Requirements:

### Area Specialization, Political Military and Strategic Planning Options

a. At least 44 quarter units of approved graduate study pertinent to the field of National Security Affairs, of which at least 16 units must be at the 4000 level.

b. The completion of an approved sequence of courses concentrating in either an area or functional specialty, including at least one 4000 level course in that specialty.

c. Successful completion of a comprehensive examination or an acceptable thesis in lieu thereof.

d. Language requirements when applicable.

### Naval Intelligence Option

a. A minimum of 44 quarter hours of graduate work, of which at least 12 quarter hours must be at the 4000 level. At least 20 hours must be in the area of national security affairs.

b. Completion of graduate courses in at least three different academic disciplines, including a 4000 level course in at least two of these disciplines.

c. Completion of an acceptable

thesis in addition to the 44 quarter hours of course work.

## NATIONAL SECURITY AFFAIRS

**NS 0010 Seminar in Naval Intelligence (0-2).**
A continuing series of colloquium seminars in subjects bearing on Naval Intelligence. Seminars will be phased with the development of the curriculum.

**NS 0011 Seminar in National Security Affairs (0-2).**
A continuing series of colloquium seminars in subjects bearing on National Security Affairs will be phased with the development of the curriculum.

**NS 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

**NS 0811 Preparation for Comprehensive Examination (0-0).**
Every student preparing for comprehensive examination will enroll in this course.

*Lower Division Course*

**NS 1368 American Life and Institutions (3-0).**
American political institutions and the political, social, economic, and cultural aspects of American life. OPEN ONLY TO ALLIED OFFICERS. Graded on Pass/Fail basis only.

*Upper Division Course*

**NS 2070 Naval Warfare and National Security (4-0).**
This is an introductory course specifically designed for students in NPS warfare curricula. It focuses on the role of the U.S. Navy as an instrument of U.S. security policy and on the Soviet Navy as the primary naval threat to U.S. interests. It places the use of both navies in the context of a dynamic naval balance and of a changing international system.

*Upper Division or Graduate Courses*

**NS 3032 Modern Revolution and Political Terrorism (4-0).**
Study of the general historical framework of modern revolution to include systematical analysis of the development of modern revolutionary situations. Examinations of the more important revolutions of modern times including study of the historical events, testing of the methods of systematic analysis, and emphasis on revolutionary tactics, e.g. political terrorism.

**NS 3061 American National Security Policy (4-0).**
An institutional and functional analysis of the national and international factors which shape U.S. defense policy. Attention in the course is focused on two major areas: 1) the decision-making process, including the legislative-executive budgetary process, as well as the influence of bureaucratic politics and interest group participation upon defense decisions; 2) the problems of strategic choice, including threat analysis, net assessment, deterrence theory, and limited war.

**NS 3062 Intelligence Data Analysis and Research Methods (4-2).**
A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of data. Topics include sampling methods, content analysis, data handling and processing, scaling techniques, and parametric and non-parametric tests, with emphasis on application to intelligence. PREREQUISITES: PS 3000 or equivalent, CS 2100. May also be offered as OS 3062.

**NS 3064 Intelligence Systems and Products (4-0).**
This course is intended for students in the command and control program. It provides an introduction to the intelligence systems and products which support command decision making, an overview of Soviet command and control concepts and practices required for an appreciation of the significance of intelligence reporting, insight into intelligence procedures to provide perspective for operational security planning and material on Soviet intelligence organizations and capabilities. PREREQUISITES: TOP SECRET clearance with eligibility for SI/SAO, U.S. Citizenship.

**NS 3078 The Politics of National and Global Economic Relations (4-0).**
An integrated analysis of the economic and political factors that together determine national and international economic arrangements. The student first addresses the general

principles of public finance as a prerequisite for the analysis of budgets, and policy priorities in specific countries and areas. The second portion of the course is concerned with the basic differences, between socialist, capitalist and market economic systems. The remainder of the course is concerned with the changing world economic order, to include issues such as trade, aid, multi-national corporations, technology and strategic resources.

**NS 3164 Comparative Ideologies (4-0).**
Analysis of the major ideological forces in contemporary world affairs and their effect upon foreign and defense policies. Special emphasis on Marxian political and social thought. Analysis and comparison on the concepts of democracy, socialism, and fascism. Use of primary source material. PREREQUISITE: A course (upper division or graduate) in the History of Western Philosophy or Political Theory, or consent of Instructor.

**NS 3169 Comparative Political Analysis and Research Methods (4-0).**
An analytical and comparative study of the form and functioning of the major types of contemporary government with emphasis on the policymaking process and research methods.

**NS 3172 Public Policy Processes (4-0).**
A presentation of the processes by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3161, MN 3105. May be given as MN 3172, or with consent of the Instructor.

**NS 3262 Theory and Practice of International Politics (4-0).**
A theoretical systematic analysis of international relations and a study of the factors, organizational strategies, and techniques of international politics.

**NS 3272 American Traditions and the National Interest (4-0).**
A study of the ideals and values which constitute the essential qualities of American life. The main purpose of this course is to define the American national interest in the international context and the effect of national security policy on the realization of national goals.

**NS 3275 International Law (4-0).**
An introduction to the principles of International Law including sovereignty, territory, recognition, the Law of the Sea, and the laws of war. Special emphasis is on the Law of the Sea, its development, practice, and prospects.

**NS 3276 The Law of War (4-0).**
The course presents and analyzes the law of war as it is to be observed and enforced by the Armed Forces of the United States. Special attention is paid to the 1949 Geneva Conventions, the Navy's *Law of Naval Warfare* and the Army's *Law of Land Warfare.*

**NS 3279 Directed Studies in National Security Affairs (Credit open).**
Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examination.

**NS 3280 Nuclear Weapons and Foreign Policy (4-0).**
An interdisciplinary course which covers both the technology and political influences of nuclear weapon systems. The course will emphasize the interaction of nuclear weapon systems with the foreign policies of the major powers and the political blocs from 1945-present.

**NS 3300 Problems of Government and Security in the Middle East (4-0).**
An introductory course in Middle Eastern society and politics designed to provide the maximum amount of broad background area knowledge to be utilized in follow-on courses in Middle Eastern politics.

**NS 3310 North Africa: Government and Security in the Maghrib (4-0).**
This course is designed to extend the student's knowledge of selected North African and Red Sea littoral countries, and to provide some insight into the security problems presented by their domestic politics. In addition, some coverage of central African countries will be included.

**NS 3312 Seminar of Middle East Oil (4-0).**

An examination of the oil resources of the Middle East for their impact upon the internal, regional, and international policies of region-states. The role of international oil companies, consuming states, and organizations of exporting countries is studied. Differences in oil resources and revenues are examined and related to different developmental and international policies. The past and future use of oil as a political weapon is discussed and evaluated. The use of revenues from oil is examined for its impact on levels of development and the regional military balance.

**NS 3314 Problems of Government and Security in Israel (4-0).**
Israeli cultural, social, and political patterns: Hebraic traditions, Zionism and the creation of Israel, institutional and sociological frameworks for Israeli politics, elite recruitment, perceptions and strategic orientations, security issues in Israeli domestic and foreign policy. PREREQUISITES: NS 3300 or NS 3331, or their equivalent.

**NS 3315 The Middle East: The Military Dimension (4-0).**
An examination of the political, sociological, cultural and strategic roles of the military in Middle Eastern history and politics. Among the topics considered are: traditional military patterns, military recruitment, organization, doctrine, and learning experiences.

**NS 3316 Problems of Government and Security in the Northern Tier: Turkey, Iran, Afghanistan, Pakistan (4-0).**
An examination of internal and external political, economic, and social forces in the major non-Arab Middle Eastern states as reflected in their internal development and international policies. Cooperation and conflict in the behavior of these nations toward each other will be explored in the context of their recent efforts at regional cooperation and regional organization (the Sa'dabad Pact, Cento, and RCD). Examination of their relationships to the major outside powers interested in the area, i.e., the U.S. and the Soviet Union. Their relationships both as individual states and as a sub-region with the Arab states of the Middle East. PREREQUISITES: NS 3300 and NS 3320.

**NS 3320 International Relations and Security Problems in the Middle East (4-0).**
The course focuses on selected problems affecting American security interests in the Middle East: Strategic waterways, including the Suez Canal, the Turkish Straits, and the Indian Ocean; the politics and problems of access to the area's oil resources; the development of U.S. and Soviet policies toward the area. The foregoing problems will be set in the context of regional international politics.

**NS 3330 Military Geography and History of the Middle East (4-0).**
An intensive course in Middle Eastern history from the viewpoint of geographical and military factors which have shaped the course of events in the area. The geographic (including oceanographic) environment within which military campaigns have been conducted, and which continues to present military problems, is examined. Indigenous and foreign techniques and tactics for dealing with this environment, as well as the historical development of Middle Eastern military organization are studied.

**NS 3331 20th Century Middle Eastern Military and Political History (4-0).**
A follow-on course to NS 3300 which continues the study of Middle Eastern history from the 19th through the 20th Century. Emphasis is placed on the political and military factors which shaped the strategic events. Special attention is given to the genesis and development of nationalist movements in the area and their impact on Middle Eastern politics. PREREQUISITE: NS 3300.

**NS 3350 Area Colloquium in Middle Eastern Studies I (2-0).**
A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

**NS 3351 Area Colloquium in Middle Eastern Studies II (2-0).**
A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and

security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

**NS 3400 Domestic Determinants of Soviet National Security Policy (4-0).**
A study of Russian and Soviet political inheritance, ideology, religion, political and economic structures, strategic posture, military capabilities, and leadership.

**NS 3410 Soviet National Security and Foreign Policy-Making Processes (4-0).**
A study of the processes which determine the national security and foreign policy of the Soviet Union. The main focus will be on foreign policy and the dynamics of decision-making in Soviet national security affairs.

**NS 3420 Soviet Naval and Maritime Strategy (4-0).**
Examination of the roles played by the Soviet Navy, Merchant Marine, Fishing Fleet, and Oceanological Establishment in securing the objectives of the Soviet Government. Topics include: geographic factors affecting Soviet ocean strategies; non-naval strategy trends; international and domestic factors affecting post-1953 naval strategy; development of Soviet naval warfare capabilities; doctrinal and functional analysis of post-1953 trends in naval strategy; command structure; personnel training; law of the sea positions; U.S.-Soviet naval interaction.

**NS 3430 Soviet Military Strategy (4-0).**
Economic, historical and geographic influences on Russian military operations and strategies emphasizing the Soviet era and alternative future Soviet military developments and strategies are examined.

**NS 3440 Comparative Communist Political Systems (4-0).**
An analysis of structure and policy-making processes of existing communist political systems, of major functions performed by them, and significant factors affecting system development.

**NS 3450 Area Colloquium in Soviet Studies I (2-0).**
A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

**NS 3451 Area Colloquium in Soviet Studies II (2-0).**
A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. **Graded on Pass/Fail basis only.**

**NS 3500 Problems of Government and Security in the Caribbean Area (4-0).**
A study of the political, economic, social, and cultural characteristics and the security problems of the countries in the Caribbean area. Included are Mexico, Central America, the Caribbean Island countries, the Guianas, Venezuela, and Colombia.

**NS 3510 Problems of Government and Security in South America (4-0).**
A study of the political, economic, social, and cultural characteristics and the security problems of the countries in South America, excluding the Guianas.

**NS 3520 Problems of Diplomacy and Security in Latin America and the Caribbean (4-0).**
A study of the political, economic, and military relationships among the Latin American nations, and the role of Latin America in world politics. Special emphasis is placed on U.S. relations with Latin America.

**NS 3605 Geography, History and Cultures of Asia (4-0).**
An introduction to Asia, including Japan, China, India, Southeast Asia, West and Central Asia. The course addresses the people and their cultures, civilizations, social organization, economic and political development through four distinct periods: before the coming of Europe, the colonial period, the era of national development and modernization, and the period since World War II.

**NS 3606 Problems of Government and Security in Peninsular Southeast Asia (4-0).**

Problems of modernization, war, and revolution in the governments and economies of the states of Peninsular Southeast Asia: cultural determinants; problems of ethnic minorities; role of religions; nationalism, communism, and wars of liberation; the overseas Chinese problem; the absorption of South Vietnam into the Democratic Republic of Vietnam; the transformation of Cambodia and Laos into Community States; the Thai and Burmese military regimes and their problems of modernization and security; the strategic interests of the major powers.

NS 3608 Problems of Government and Security in Insular Southeast Asia (4-0).
Problems of modernization, war and revolution in the government and economies of the states of Insular Southeast Asia: cultural determinants; problems of ethnic minorities; roles of religions; nationalism, communism, and wars of liberation; the overseas Chinese problem; communal and leadership problems in Malaysia, Republic of Singapore, Philippines, and Indonesia. Problems of security; the strategic interests of the major powers.

NS 3610 Problems of Government and Security in East Asia and the Pacific Ocean (5-0).
Problems of industrialization, revolution, and conflict in the East Asian States: China's relations with contiguous states; Sino-Soviet state, party, and ideological differences; Chinese military and naval command structure; Japan's new dynamic position; U.S. and Japanese security issues; problems of the two Koreas; Soviet and American Far Eastern interests and policies; analysis of present and future military capabilities and strategies of East Asia States.

NS 3611 Problems of Government and Security in Contemporary Japan (4-0).
A study of contemporary Japan since the end of World War II: Occupation policies of the U.S.; the new Constitution; revival and nature of Japanese party government; parties and their platforms; styles of leadership; Japanese economic policies; access to resources; the energy problem; urbanization and breakdown of old value systems. Japan's security problems; Korea; the approach of separating politics and economics; the two-China problem; relations with the Soviet Union; the nuclear problem; relations with Europe; the security relationship of the U.S. and Japanese armed forces.

NS 3612 Problems of Government and Security in the People's Republic of China (4-0).
A study and analysis of Communist China since the end of World War II: The structure of government and party; the CCP, history, facts, legends and leaders; the politics of a communist system. Population; land reform and the organization of the agricultural sector; industrialization and expansion of China's resource base; the People's Liberation Army, its command structure, political role, ground forces, navy, air force, and nuclear weapons systems; China's foreign and international security policies; relations with the Soviet Union, Japan, Southeast Asia, South Asia, and Third World Countries; the nature and significance of relations with the United States.

NS 3620 Problems of Government and Security in South Asia and the Indian Ocean (4-0).
Problems of nationalism, modernization, and security in the governments and economies of India. Pakistan, Bangladesh, Afghanistan, and Sri Lanka. Indian-Pakistani relations; relations with China; the Tibetan and Kashmir problems; strategic interests of the major powers; Soviet interests and naval expansion in the Indian Ocean.

NS 3650 Area Colloquium in Asian Studies I (2-0).
A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3651 Area Colloquium in Asian Studies II )2-0).
A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3700 Strategic Geography and the History of Europe (4-0).
The course links the political and military experiences of the European states and political blocs of the 19th and 20th Centuries with the

decisive constraints and opportunities of geography. The advanced elements of geography, which serve as the fundamental framework in political and military decision-making, are systemically arranged and examined within Europe. Strategic position, area, physiography, population, technology and economic resources are presented as the basic elements which have influenced the political and military events of the recent past and can be used to help in forecasting the future.

**NS 3701 Recent History of Europe and the U.S.S.R. (4-0).**
This course continues the narrative and analysis begun in NS 3700 Strategic Geography and History of Europe, bringing the student from the Bolshevik Revolution and the Treaty at Versailles to the present day.

**NS 3710 International Relations and Security Problems of the Mediterranean (4-0).**
This course is designed to provide an introduction to security problems in and around the Mediterranean. It will focus on the strategic problems of access to, and defense of the Mediterranean litoral: communication routes in and through the Mediterranean; Western and Soviet interests in the Mediterranean; politics and policies of the surrounding states.

**NS 3720 Problems of Government and Security in Contemporary Europe (4-0).**
Problems of the European political system since World War II. Emphasis on the interrelation of European states (EEC and CMEA), the polarization of Europe between two security systems (NATO and the Warsaw Pact) and relations between the European states and the Third World.

**NS 3740 Problems of Government and Security of the Scandinavanian-Baltic Region (4-0).**
This course analyzes the political, economic, social, and security problems faced by the Scandinavian-Baltic countries. The role they play on the northern flank of NATO will be examined as well as their position vis-a-vis the growing threat of Soviet military and naval power in the Baltic and Norwegian seas.

**NS 3750 Area Colloquium in European Studies I (2-0).**
A combined NSP/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. **Graded on Pass/Fail basis only.**

**NS 3751 Area Colloquium in European Studies II (2-0).**
A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. **Graded on Pass/Fail basis only.**

**NS 3811 Military Geography and History of Africa (4-0).**
The course examines the major geographic regions of the continent (North Africa, West Africa, East Africa, Southern Africa and Central Africa) in terms of their communications, natural resources and environmental factors which have influenced their historical development. Major military campaigns, tactics and strategy of indigenous and foreign forces will be examined. Particular attention will be given to military forces and conflicts of post colonial Africa, the role of the military in the consolidation of national states, and the involvement of foreign forces in internal and regional conflicts.

**NS 3813 Problems of Government and Security in Sub-Saharan African (4-0).**
Emergence of independent African states from a shared colonial heritage and their common problems in developing viable modern nation-states. Patterns of international cooperation and conflict among African states, including discussions of African socialism, negritude, pan-Africanism, neutralism, and the continuing problem of South Africa's future. Rival policies of outside powers, including the U.S., the Soviet Union, China and the former colonial powers.

**NS 3820 Great Powers in Africa (4-0).**
A comparative analysis of the great powers and their foreign policies in Africa. This course focuses on USSR and USA, but also deals with the limited Chinese involvement. The effects of

great powers and trans-national forces on African states. The bargaining power of African states in relation to great powers. Analysis of national liberation movements and their potential competition in Southern Africa in the mid 1970's.

**NS 3830 African Political Organizations, Parties and Bureaucracies (4-0).**
An overview of the sociological and organizational structures which shape African polities: This course will focus on a comparative analysis of African party systems, especially the dynamics of non-party states; an analysis of African bureaucratic traditions and the impact of strategies of modern ratio on these traditions; an overview of cooperative policy formation in selected African governments.

**NS 3850 Area Colloquium in African Studies I (2-0). NS 3851 Area Colloquium in African Studies II (2-0).**
Combined NPS/DLI colloquia. Open to students completing their language studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Grades on Pass/Fail basis only.

**NS 3900 International Organization (4-0).**
Analysis of the international system, its evolution from separatism and alliances to multinational organization and beyond. American goals, objectives, and resources are examined in bilateral relationships, regional groupings, functional approaches, and general organization. Collective security and peacekeeping efforts, pacific settlement, arms control and disarmament, and institution building.

**NS 3901 Ocean Policy (4-0).**
Examination of policy choices for the United States and other governments concerning political, military, legal, environmental, and economic problems of the sea.

**NS 3902 Science, Technology, and Public Policy (4-0).**
An inquiry into the role of science and technology in the formulation and conduct of national policy. Interactions between scientific communities, government, and military services.

*Graduate Courses*

**NS 4000 Perspectives on American Civilization (4-0).**
This course, especially designed for the foreign area studies (attache) program, is an interdisciplinary study of American culture, involving the political, economic, social, philosophical and literary development of the Nation from 1789 to the present.

**NS 4061 Survey of Strategic Studies (4-0).**
An extensive survey of the classical and contemporary literature on strategic thinking; national objectives and strategic alternatives; deterrence, counterforce, arms control, counter insurgency, compellence; components and rules of the international strategic system; arms competitions, nuclear proliferation, terrorism. Student projects on current strategic problems are a major component of the course. PREREQUISITES: NS 3601, NS 3262.

**NS 4063 Naval Threat Analysis (4-0).**
Introduction to different types of naval threat analyses and to the purposes, problems and procedures associated therewith. Attention is paid to sources of information available to analysts and to threat analysis products put out by the U.S. Intelligence activities. Students will engage in a classroom simulation of an operational intelligence activity charged with analyzing a "developing threat." SI access required.

**NS 4064 Comparative Command, Control, Communications and Ocean Surveillance (3-0).**
An examination of the command and organizational structures, control philosophies, communications systems and ocean surveillance systems of the Soviet and US Navies. The course begins with the Soviet approach which is used as a basis of comparison with the US approach. Possible exploitable features of the command and control structure are considered. The course emphasizes readings in the appropriate literature, research and seminar discussions. PREREQUISITES, NS 3420, TOP SECRET clearance with access to special intelligence information. SE 2003, OS 3207 or equivalent. *May also be taught as SE 4064.*

**NS 4077 Strategic Resources and U.S. National Security Policy (4-0).**
Analysis of the problems of access to global resources and their utilization: agricultural production; access to critical raw materials; problems and politics of oil; national and international implications of various strategies of self-sufficiency and interdependency. Emphasis is placed on the security problems arising from the geographic distribution of international resources. PREREQUISITES: NS 3061, NS 3262.

**NS 4140 Problems of Security Assistance and Arms and Transfers (4-0).**
An analysis of the patterns, purposes and effects of cross-national security assistance, including arms sales and the transfer of technology. Special topics include: factors dominating the arms transfer policies of the major powers; the role of the military in recipient nations; the role of the military attache; the design, execution and evaluation of security assistance programs. PREREQUISITES: NS 3061 or NS 3262.

**NS 4161 American National Security Objectives and Net Assessment (4-0).**
Comparative analysis of trends in U.S. and Soviet security policy, military forces, manpower, and capabilities. Special attention is paid to familiarizing students with original source material and major elements in current controversial national security issues. Topics covered include nuclear capabilities and doctrine, BMD and air defenses, civil defense, combined arms employment NATO Warsaw Pact military balance, naval forces, and trends in the U.S. and Soviet economies especially as they affect the allocation of resources to defense.

**NS 4207 Special Topics in the Analysis of Intelligence Problems (4-0).**
An examination of special intelligence problems and cases with emphasis on problem and project formulation, structure, and management as well as the interpretation and communication of study results. The last portion of the course will focus on student presentation of thesis research. PREREQUISITES: NS 3062, OS 3207, NS 4063.*May also be taught as OS 4207.*

**NS 4273 American Foreign Policy and World Politics (4-0).**
An advanced study of the underlying assumptions and objectives of American security and foreign policy. Policy formulation, world politics, alliance and treaty systems; effects on security problems of budgets, weapons systems, research and development, international economic issues, the functioning the regional security systems in crises; problems of threat and intelligence determination. Use of primary source material. This course is designed to develop a capacity for problem analysis or to encourage opportunities for research specialization. PREREQUISITES: NS 3400, NS 3610.

**NS 4279 Advanced Directed Studies in National Security Affairs (Credit open).**
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

**NS 4300 Seminar in Security Problems of the Middle East (4-0).**
Advanced Middle Eastern politics and the security problems they present to U.S. decision-makers. The central theme of the course is U.S. interests in the Middle East, how these interests are threatened, and what policy alternatives have been proposed to secure them. PREREQUISITE: NS 3300 or NS 3320.

**NS 4330 Seminar in Middle Eastern Civilizations (4-0).**
Description and analysis of the four major cultural traditions of the Middle East: Arabic, Persian, Judaic, and Turkish. Students read translations of selected classical and contemporary writings from each of these traditions, and secondary materials concerning social and cultural institutions. PREREQUISITES: NS 3300 or NS 3330 or consent of the Instructor.

**NS 4400 Seminar in Soviet Security Problems (4-0).**
Course is designed to provide students with an opportunity to engage in advanced study and research in specialized topics relating to the

USSR. PREREQUISITES: Two 3000 level courses on the Soviet Area.

**NS 4425 Advanced Topics in Soviet Naval Affairs (4-0).**
Advanced study and research in Soviet naval and maritime affairs. Topics include: decision-making processes, scenarios, warfare capabilities and support systems, missions; and U.S.-Soviet naval interactions.

**NS 4630 International Security Problems of Asia and the Adjacent Oceans (4-0).**
An advanced study of the international security interests and problems of the Asian states: changing military capabilities and the balance of forces; problems of military and naval threats; economic resources for war; alliances, bases, and security systems; forecasting of international conflict on the continent; assessment of the Asian policies of the U.S. PREREQUISITES: 8 units of Asian studies or consent of the Instructor.

**NS 4700 Seminar in Soviet-European Relations (4-0).**
A seminar intended to deepen the student's knowledge of current issues in Soviet and European affairs through weekly presentations and discussions by visiting scholars and government officials and by the preparation and presentation of the students' own research papers.

**NS 4701 Seminar in Political and Security Problems of Europe (4-0).**
A research seminar on political and security issues in contemporary Europe. Students conduct and present original research on a selected issue, or related issues, in specific European countries or subregions. The issue around which the seminar is structured varies from term to term. It is chosen to meet the research interests of each group of students enrolled in the course.

**NS 4710 Seminar in Sino-Soviet Relations (4-0).**
Advanced analysis of Sino-Soviet relations. Emphasis is placed on political, economic and military factors which have shaped historical confrontations and contemporary conflicts, and which will influence the policies of both nations in the future. The special features of the course include consideration of the influence of Sino-Soviet conflicts upon global military and diplomatic problems. Open to Asian and Soviet Studies students and to other students with consent of the Instructor.

**NS 4800 Culture and Civilizations of Africa (4-0).**
Description and analysis of the major cultural traditions in Africa: the historical, intellectual and religious sources of African cultures; their impact on contemporary African ideological and political predispositions; the interaction of indigenous traditions with each other and with non-African cultural imports.

**NS 4810 Seminar in African Politics (4-0).**
The central theme of the course is U.S. interests in Africa, how these interests are threatened, and what policy alternatives have been proposed to secure them. Advanced African politics and the security problems they present to U.S. decision-makers. PREREQUISTES: NS 3313, NS 3830 or NS 3820.

**NS 4900 Seminar in Ocean Policy (4-0).**
An advanced survey of the oceanographic, military, political and legal problems of the oceans. Among the topics to be dealt with are; comparative regional military oceanography, politics and strategy of fleet deployment, and international legal constraints on naval operations.

# DEPARTMENT OF OCEANOGRAPHY

**Dale Frederick Leipper,** Professor of Oceanography; Chairman (1968);* B.S., Wittenberg Univ., 1937; M.A., Ohio State Univ., 1939; Ph.D., Scripps Institution of Oceanography (La Jolla), 1950; Hon. D.Sc., Wittenberg Univ., 1968.

**Robert Sanborn Andrews,** Associate Professor of Oceanography (1968); B. of Geol. Engr., Univ. of Minnesota, 1958; M.S., Univ. of Washington, 1965; Ph.D., Texas A&M Univ., 1970.

**Miah Allan Beal,** Adjunct Research Professor of Oceanography; Chair in Arctic Marine Sciences (1977); B.S., Univ. of Maine, 1952; M.S., Scripps Institution of Oceanography (LA Jolla), 1960; Ph.D., Oregon State Univ., 1968.

**Robert Hathaway Bourke,** Associate Professor of Oceanography (1971); B.S., Naval Academy, 1960; M.S., Oregon State Univ., 1969; Ph.D., 1972.

**Alden Buffington Chace, Jr.,** Lieutenant Commander, U.S. Navy; Assistant Professor of Oceanography (1976); B.S., Naval Academy, 1962; M.S., Naval Postgraduate School, 1969; Ph.D., Univ. of Rhode Island, 1976.

**Warren Wilson Denner,** Associate Professor of Oceanography (1964); B.S., Portland State College, 1961; M.S., Oregon State Univ., 1963; Ph.D., 1969.

**Roland William Garwood, Jr.,** Adjunct Research Professor of Oceanography (1976); B.S., Bucknell Univ., 1967; Ph.D., Univ. of Washington, 1976.

**Eugene Clinton Haderlie,** Distinguished Professor of Oceanography (1965); A.B., Univ. of California at Berkeley, 1943; M.A., 1948; Ph.D., 1950.

*Research vessel ACANIA is used for experiments leading to improved understanding of the oceans and the overlying atmosphere.*

**Glenn Harold Jung,** Professor of Oceanography (1958); B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas A&M Univ., 1955.

**Louis Henry Knipling, Jr.,** Colonel, U.S. Army; Assistant Professor (1976); B.S., Carnegie Tech., 1948; M.S., Ohio State Univ., 1956; Ph.D., 1973.

**Donald Eugene Nortrup,** Commander, NOAA; Instructor in Hydrography (1977); BSCE, Univ. of Missouri at Rolla, 1965; MSCE, 1967; MPA, Univ. of Washington, 1975.

**Robert George Paquette,** Professor of Oceanography (1971); B.S., Univ. of Washington, 1936, Ph.D., 1941.

**Andreas Buchwald Rechnitzer,** Adjunct Professor of Applied Oceanography (1977); B.S., Michigan State Univ., 1947; M.A., Univ. of California at Los Angeles, 1951; Ph.D., Scripps Institution of Oceanography, 1948.

**Edward Bennett Thornton,** Associate Professor of Oceanography (1969); B.A., Williamette Univ., 1962; B.S., Stanford Univ., 1962; M.S., Oregon State Univ., 1965; M.E.C.E., Univ. of Florida, 1966; Ph.D., 1970.

**Eugene Dewees Traganza,** Associate Professor of Oceanography (1970); B.A., Indiana Univ., 1955; M.S., Texas A&M Univ., 1959; Ph.D., Univ. of Miami, 1966.

**Stevens Parrington Tucker,** Assistant Professor of Oceanography (1968); B.S., Stanford Univ., 1955; M.S., Oregon State Univ., 1963; Ph.D., 1972.

**Joseph John Von Schwind,** Associate Professor of Oceanography (1967); B.S., Univ. of Wisconsin, 1952; M.S., Univ. of Utah at Salt Lake City, 1960; Ph.D., Texas A&M Univ., 1968.

**Jacob Bertram Wickham,** Associate Professor of Oceanography (1951); B.S., Univ. of California at Berkeley, 1947; M.S., Scripps Institution of Oceanography, 1949.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

Oceanography is the study of the sea from the points of view of the basic sciences: physics, biology, chemistry, and geology. It emphasizes relationships with engineering and meteorology. Hydrography (at times referred to as mapping, charting and geodesy or M.C.&G.) is the science of the measurement, description, and mapping of the surface waters of the earth, with special reference to their use for navigation and operations. The Department of Oceanography is the center for these studies at the Naval Postgraduate School. Its functions are to prepare officers to make best use of the ocean environment in the course of their duties, and to prepare them to carry out and evaluate research in oceanography and hydrography, both basic and applied.

The curriculum and the research vessel are sponsored by the Oceanographer of the Navy. Research is supported through contracts with various government agencies including the Office of Naval Research.

## DEPARTMENT REQUIREMENTS FOR DEGREES IN OCEANOGRAPHY

### MASTER OF SCIENCE IN OCEANOGRAPHY or MASTER OF SCIENCE IN OCEANOGRAPHY (HYDROGRAPHY)

Entrance to programs leading to these masters degrees require a baccalaureate degree in a field ap-

propriate to the oceanography option chosen. Minimal requirements include mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry. Previous experience at sea is considered advantageous.

The masters degree programs require:

a. Completion of thirty-five quarter hours of graduate courses of which fifteen hours must be in the 4000 Oceanography series. The entire sequence of courses for the particular option selected must be approved by the Department of Oceanography.

b. For the Hydrography option, OC 3902, 4906, 3903, 3904, 3905, 3909, 4212 and 4907 are required.

c. An acceptable thesis on a topic approved by the Department of Oceanography.

## MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. *Direct* entrance to a program leading to the degreeMaster of Science in Meteorology and Oceanography requires a baccalaureate degree in meteorology and/or oceanography or equivalent. This normally permits the validation of required undergraduate courses such as physics, chemistry, differential equations, linear algebra, vector analysis and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event the program may be lengthened by one or two quarters.

*Indirect* entry into the program is possible for persons lacking a baccalaureate degree in meteorology or oceanography through the oceanography curriculum (440). Minimal entrance requirements here include differential and integral calculus, and a year each of college physics and chemistry.

2. The degree of Master of Science in Meteorology and Oceanography requires:

a. Completion of 48 quarter hours of graduate courses in meteorology and oceanography including MR/OC 4413, MR 4322, MR 4323 and 10 quarter hours in the 4000 oceanography series. The degree program must be approved by both the Department of Meteorology and the Department of Oceanography.

b. Completion of an acceptable thesis on a topic approved by either department.

## DOCTOR OF PHILOSOPHY

Department of Oceanography admission requirements for the degree of Doctor of Philosophy are:

a. a Master's degree (or the equivalent) in science or engineering or

b. a Bachelor's degree with a high QPR or

c. a successful first graduate year on a Master's program, with clear evidence of research ability.

A student who desires to undertake doctoral work in oceanography should discuss his program first with the Chairman, Department of Oceanography. He should then follow regular guidelines as outlined by the Curricular Officer and the Academic Associate.

## LABORATORY FACILITIES

The department has two beachfront laboratories, a small biological oceanography laboratory with salt water aquaria and filtered salt water circulating system and a 4,000 square-foot laboratory with lecture room and student study areas. Equipment includes a wave tank, drying oven, and high pressure test chamber. Additionally, a small ocean engineering laboratory, chemical oceanography laboratory, and geological oceanography laboratory are maintained.

The School operates the R/V ACANIA, a 126-foot vessel, for use in oceanographic instruction and research.

Oceanographic equipment installed in the beach area includes wave and tide gauges for recording nearshore wave action and local tide fluctuations.

### OCEANOGRAPHY

**OC 0110-11-12 Applications Seminars (1-0).**
Presentation of DOD related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students visiting authorities. OC 0110 is for orientation; OC 0111 is for beginning students; OC 0112 is for advanced students. PREREQUISITE: Enrollment in an Environmental Sciences curriculum.

**OC 0810 Thesis Research (0-0).**
Every student conducting thesis research will enroll in this course.

**OC 0999 Seminar in Oceanography (2-0).**
Students in the various oceanography curricula report results of their own research in presentations for group discussion. PREREQUISITE: Preparation of a thesis or a research paper concurrently.

*Upper Division Courses*

**OC 2110 Introduction to Oceanography (3-0).**
An introductory course treating physical and chemical properties of sea water, submarine geology, and marine biology; the heat budget of the oceans; water masses and general circulation; currents, waves, and tides. PREREQUISITE: None.

**OC 2120 Survey of Oceanography (4-0).**
Beginning physical oceanography, average values of ocean parameters, an integrated view of the whole field of oceanography including biological, geological, and chemical. PREREQUISITE: Calculus and college physics, or permission of Instructor. (May be taken through Continuing Education as the minicourse sequence OC 2121-24.)*

**OC 2430 Environmental Pollution (3-0).**
A survey of air and water pollution theory and associated problems with specific case studies. Pertinent basic principles from oceanography and meteorology will be presented. PREREQUISITE: None. May also be offered as MR 2430.

**The minicourses are described in the Continuing Education catalog.*

*Upper Division or Graduate Courses*

**OC 3150 Geophysical Random Processes (4-2).**
Statistical evaluation of measurements in random media: ocean, atmosphere, earth; basic probability, probability distributions, probability density functions; random variables, random functions; harmonic analysis of random functions. Time series analysis: covariance, con-

volution, energy density spectrum, cross spectrum. PREREQUISITES: MA 2121, MA 3132, OC 3221, OC 4211 Concurrently.

OC 3212 Polar Meteorology/Oceanography (3-1).
Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea-ice; its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Aspects of geology and geophysics. PREREQUISITES: MR 3230, OC 3221.

OC 3220-3221 Physical Oceanography I-II (3-0).
Beginning physical oceanography; the ocean basins, age and origin of oceans, physical properties of sea water, thermal properties of water and ice, distribution of variables, physical characteristics of estuaries. Ocean current systems, water masses, geostrophic flow, dynamic height computation, upwelling, heat budget, heat distribution and thermal structure, waves, internal waves and tides, selected regional studies in physical oceanography. For oceanography and air-ocean science majors.

OC 3240 Operational Environmental Products (0-4).
Meteorological and oceanographical products available to the operating fleet from Fleet Numerical Weather Central/Fleet Weather Centrals, Naval Oceanographic Office and other sources and described and applied to the diagnosis and prognosis of tactical environmental parameters for both current and historical situations. PREREQUISITES: MR 2210 and OC 3221.

OC 3261 Oceanographic Factors in Underwater Sound (4-0).
This course examines the environmental factors which influence sound propagation in the ocean and the effects these factors have in acoustic forecasting. Factors considered include temporal and spatial variations in sound velocity profiles, ambient noise, biological effects, reflection characteristics of ocean surface and bottom, signal fluctuations, and forecasting ocean thermal and sound speed structure. The students will review and report on related papers from the current literature. This course is designed for the Engineering Acoustics Curriculum. PREREQUISITES: PH 3452, OC 2120.

OC 3265 Environmental Factors in Underwater Acoustics (4-0).
This course examines the environmental factors which influence sound propagation in the ocean. Factors considered include temporal and spatial variations in sound velocity profiles, ambient noise, radiated noise, absorption, reflection characteristics of the sea surface and ocean bottom, signal fluctuations, and transmission loss models. This course is designed for the ASW curriculum. PREREQUISITES: OC 2120, MR 3413, PH 3471.

OC 3320 Geological Oceanography (3-3).
Geological processes, materials, and methods in marine geology; physiography of the sea floor; sedimentology; marine geophysics surveys; properties and distribution of recent marine sediments, especially as relevant to underwater acoustics; structure and origin of ocean basins; field trips to local sites and aboard oceanographic research vessel. PREREQUISITE: OC 2110 or OC 2120 or OC 3220.

OC 3321 Marine Geophysics (3-0).
Theory and methods of marine geophysics surveys, with emphasis on gravity, magnetism, seismic and acoustic wave propagation, heat flow, and radioactivity; geophysical anomalies associated with major seafloor features; acoustic reflectivity of the sea floor; marine geodesy. PREREQUISITE: OC 3320 or OC 3323.

OC 3322 Principles of Geology (2-0).
Survey of physical geology directed toward processes, materials, and methods in marine geology; geologic time, minerals and rocks, structural geology, weathering, gradation, and earth physics. PREREQUISITE: OC 2110 or OC 2120 or OC 3220 or college introductory oceanography.

OC 3323 Geological Oceanography (2-0).
Physiography of the sea floor; sedimentology; marine geophysics surveys; properties and distribution of recent marine sediments, especially as relevant to underwater acoustics; structure and origin of ocean basins. PREREQUISITE: OC 3322 or college geology and introductory oceanography.

OC 3420 Biological Oceanography (3-3).
General biological principles; the sea as an environment for life; major plant and animal groups in the sea; plankton and food cycles; primary productivity; boring and fouling organisms; bioacoustics, bioluminescence, and deep scattering layers; dangerous marine organisms. Laboratory work and field trips dealing with marine organisms. PREREQUISITE: None.

OC 3520 Chemical Oceanography (3-3).
Basic chemistry of solutions; chemical compositions of the oceans (dissolved solids, gases, nutrients, etc.); distribution of constituents in the ocean; analytical methods used in chemical oceanography; carbonate, nutrient, and other cycles in the seas; desalination; corrosion, geochemistry. PREREQUISITES: OC 3221, CH 1001 or CH 2001 or equivalent.

OC 3610 Ocean Wave Forecasting (2-2).
Prediction and observation of wind-generated ocean waves in deep water, interpretation of wave characteristics in spectral and statistical terms for operational briefings, and wave-related influences on operations. PREREQUISITES: OC 4211, OC 3150.

OC 3617 Acoustical Forecasting (2-2).
Development of synoptic prediction techniques applied to the upper ocean and other environmental factors affecting underwater sound propagation. Current acoustical models, oceanographic input to the models and the tactical and strategic utilization of the output are described. Laboratory exercises illustrate principles developed during lectures. PREREQUISITE: OC 4260.

OC 3621 Regional Military Oceanography (1-4).
Application of the full breadth of the oceanography program, including physical phenomena, geology, biology, chemistry, acoustics and air/sea interaction in order to objectively analyze the significance of the total environment on the various aspects of naval warfare for specific oceanic areas of operation. PREREQUISITES: OC 3221, 3320, 3420, 3520.

OC 3625 Environmental Prediction for Underwater Sound Propagation (2-1).
Development of synoptic prediction techniques applied to environmental factors affecting underwater sound propagation. These factors include space and time variation of ocean density structure and associated parameters, behavior of vertical and horizontal temperature gradients, air-sea interaction, advection and mixing effects on ocean density structure. Current acoustic forecasting models will be studied in light of adequacy of environmental input data, realism, and computational approximations. This course is designed for the ASW program. PREREQUISITES: OC 2120, PH 2472, MR 3413.

OC 3709 Scientific Cruise Experience (0-4).
Laboratory course taught to introduce the student to oceanographic operations at sea. The use of standard oceanographic instruments is stressed in the conduct of a comprehensive oceanographic survey; processing of data and storage of data and samples are studied and accomplished. Interpretation of results is introduced. PREREQUISITES: OC 3820 and OC 2110 or OC 2120 or OC 3221.

OC 3801 Ocean Operations I (3-1).
This course includes a comprehensive coverage of the present state-of-the-art associated with types of floating platforms; stationary platforms; submersible design, operation, and applications; manipulator design; diving operations; underwater construction and structure; energy sources; pressure vessels and testing programs; unmanned vehicles and platforms; deep drilling; dynamic positioning; buoys and deep water buoyancy; in general those operations associated with search, rescue, recovery, and salvage. Field trips made to laboratories deeply involved in oceanographic engineering work. PREREQUISITES: None.

OC 3820 Principles of Measurement (3-2).
The application of the basic principles of mechanics, heat, electricity, sound and optics to oceanographic instrumentation employed by the Navy. Upper air and satellite developments; design and operation of oceanographic instruments; recording of oceanographic observations. PREREQUISITE: MA 2121.

OC 3902 Basic Hydrography (3-3).
Introduction to hydrographic surveys, their purpose and uses including relationship to nautical charts. Introduction to survey procedures, accuracy standards, and various com-

ponents of survey. Preparation of survey requirements and preliminary survey planning. PREREQUISITES: OC 3221, OC 3320.

OC 3903 Photogrammetry (3-2).
Principles and fundamentals of photogrammetry. Planning and executing photogrammetric projects. Principles and applications of remote sensing. PREREQUISITES: Calculus and college physics, or permission of Instructor.

OC 3904 Hydrographic Measurements (3-2).
Methods and means of conducting hydrographic survey operations. Includes sounding systems, visual and electronic control systems, tidal measurements, vertical and horizontal control, and basic photogrammetry. Sources of error, correction methods, and automation. PREREQUISITE: OC 3902.

OC 3905 Hydrographic Operations (3-2).
Hydrographic survey project planning. Selection of appropriate methods and equipment, project layout and scheduling. Data interpretation, reduction, presentation and quality evaluation. (Project plan to be implemented in OC 3909.) PREREQUISITE: OC 3904.

OC 3909 Hydrographic Cruise (0-4).
Accomplishment of complete, but small, hydrographic survey. Includes all hydrographic support activities, data acquisition and reduction, and data presentation. PREREQUISITE: OC 3904.

*Graduate Courses*

OC 4211 Waves and Tides (4-0).
Linear theory of surface and internal waves; theory of finite amplitude waves; windwave spectra; theory of the astronomical tides; tide analysis and prediction; seiches and co-oscillations. PREREQUISITE: OS 4321 or MR 4321 or ME 2201.

OS 4212 Tides (1-0).
Ocean tides and their application to vertical control and leveling.

OC 4213 Coastal Oceanography (3-2).
Shoal-water wave processes, breakers and surf; nearshore water circulations; beach characteristics; littoral drift; coastal hydraulics, storm tides. PREQUISITE: OC 4211.

OC 4260 Sound in the Sea (4-0).
Oceanographic effects on sound propagation, especially on absorption, reflection, refraction; scattering, ambient noise; operational aspects for Navy use. Synoptic prediction techniques applied to the upper ocean involving a practical approach to the solution of heat budget, techniques for forecasting the thermal structure and regional variance of oceanic acoustic properties. PREREQUISITES: PH 3431 or 3432.

OC 4321 Introductory Geophysical Fluid Dynamics (4-0).
Development of the hydrodynamical equations, vector and tensor operations, forces acting on fluids (surface forces, body forces); stream function, velocity potential, geostrophic, gradient and inertial flows; baroclinic and barotropic fluids, vertical variation of horizontal velocity; Ekman spiral applied to ocean and atmosphere; geopotential surfaces, level of no motion; vorticity and divergence equations. PREREQUISITES: MA 2048 and MA 2121.

OC 4322 Ocean Dynamics (4-0).
The wind-driven ocean circulation, real fluid boundary conditions, steady-state linear theories, steady-state non-linear theories, vorticity arguments; topographical influence on ocean currents, significance of inertial and frictional terms in an ocean with bottom topography; time dependent motion, Rossby waves. PREREQUISITE: OC 4321.

OC 4413 Air-Sea Interaction (4-0).
Consequences of momentum, heat and moisture exchange between atmosphere and ocean; recent semiempirical formulae relating air-sea fluxes to large-scale meteorological parameters; concepts in turbulence and similarity theory for stationary turbulent regimes adjacent to the air-sea interface; turbulence sensors, bulk aerodynamic formulae for estimating air-sea boundary fluxes; mutual atmosphere and ocean response times and synoptic scale energy exchanges; investigations of the role of the atmosphere and oceans of global energy balance and climate formation. PREREQUISITES: OC 3150, OC 4322 or MR 4322, MR 2210, or consent of Instructor.

OC 4421 Marine Ecology (1-4).
The habits, classification, development and

adaptations of marine animals and plants with particular reference to ecology of Monterey Bay. The relationships of physical, chemical, geological, and biological factors of the environment to marine organisms. Primarily laboratory investigations and field work dealing with the interidal areas, harbors, estuaries, and the near-shore pelagic and benthic environments of the associated organism. PREREQUISITE: OC 3420.

**OC 4422 Marine Biodeterioration (1-1).**
A study of the organisms involved in the biodeterioration of engineering materials. Subjects included are marine fouling, wood and rock borers, and the effects of biological organisms on the corrosion of metals. PREREQUISITE: OC 3420.

**OC 4612 Polar Oceanography (3-2).**
Oceanographic and geophysical structure of the polar regions; sea-ice properties, formation, growth, deformation and disintegration; sea-ice drift due to wind and currents. The course is frequently conducted as a two-week course with field experience at the Naval Arctic Research Laboratory, Barrow, Alaska. Laboratory studies of the physical, chemical, petrographic structure and strength properties of ice are combined. PREREQUISITE: OC 3221.

**OC 4800 Special Topics in Oceanography (1-0 to 4-0).**
Independent study of advanced topics in oceanography not regularly offered. PREREQUISITE: Consent of the Department Chairman and Instructor.

**OC 4802 Ocean Operations II (3-1).**
Considerations of more complex aspects of oceanographic engineering operations, including such subjects as deep mooring techniques; platform and ship motions; large object towing forces; heavy lifts and line dynamics; wave loads on platforms and floating breakwaters; hydrodynamic aspects of falling objects; considerations of high pressure structural design; participation in a laboratory exercise involving conducting an oceanographic engineering operation at sea. PREREQUISITE: OC 3801.

**OC 4803 Physical Properties of Marine Sediments (2-3).**
This course involves the elementary study of the physical behavior of marine sediments including such subjects as types of sediments, coring and testing equipment, general physical characteristics of sediments, methods of detailed physical and chemical analysis, in-situ testing, pressure effects, scour and fill, turbidity flows. Application is made to penetration and breakout of objects and to trafficability. PREREQUISITE: OC 3320.

**OC 4860 Physics of the Earth (3-0).**
Physical properties and compositions of the earth's interior; review of the theories of the earth's formation; study of the crustal structure through gravity, magnetic, seismic, and other geophysical evidence. PREREQUISITE: OC 3320 or consent of the Instructor.

**OC 4906 Geodesy (4-0).**
This course examines classical geodesy dealing with the properties of the ellipsoid. calculation of triangulation, and computations on the ellipsoid; geodetic astronomy with the determination of latitude, longitude, and azimuth; coordinate systems and their relationships; electronic surveying; and finally physical geodesy, leveling, satellite geodesy, and adjustment computations. PREREQUISITE: Calculus, college physics, OC 3321, or permission of Instructor.

**OC 4907 Cartography (3-2).**
Introduction to basic considerations in cartography with emphasis on types and mathematical generation of projections. Chart production and uses of specialized maps and charts in the DoD. Automated cartography. PREREQUISITES: Calculus and college physics, or permission of the Instructor.

# DEPARTMENT OF OPERATIONS RESEARCH

*Students conduct memory experiment involving effect of oxygen in human factors laboratory.*

**Michael Graham Sovereign,** Professor of Operations Research; Chairman (1970)*; B.S., Univ. of Illinois, 1959; M.S., Purdue Univ., 1960; Ph.D., 1965.

**Alvin Francis Andrus,** Associate Professor of Operations Research and Statistics (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

**Donald Roy Barr,** Professor of Operations Research and Statistics (1966); B.A. Whittier College, 1960; M.S. Colorado State Univ., 1962; Ph.D., 1965.

**Gerald Gerard Brown,** Associate Professor of Operations Research and Computer Science (1973); B.A., California State Univ. at Fullerton, 1968; M.B.A., 1969; Ph.D., Univ. of California at Los Angeles, 1974.

**Joseph Henry Cyr, Jr.,** Lieutenant Commander, U.S. Navy; Assistant Professor of Operations Research (1973); B.S., Purdue Univ., 1960; M.S. Naval Postgraduate School, 1969.

**James Daniel Esary,** Professor of Operations Research and Statistics (1970); A.B., Whitman College, 1948; M.A., Univ. of California at Berkeley, 1951; Ph.D., 1957.

**Robert Neagle Forrest,** Associate Professor of Operations Research (1964); B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

**Donald Paul Gaver, Jr.,** Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D., Princeton Univ., 1956.

**James Kern Hartman**, Associate Professor of Operations Research and Administrative Sciences (1970); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967: Ph.D., Case Western Reserve Univ., 1970.

**Gilbert Thoreau Howard,** Associate Professor of Operations Research (1967); B.S., Northwestern Univ., 1963; Ph.D., Johns Hopkins Univ., 1967.

**Edward Peter Kelleher, Jr.,** Lieutenant Colonel, U.S. Army; Instructor in Operations Research (1978); B.S., Boston College, 1960; M.S., Naval Postgraduate School, 1977.

**Harold Joseph Larson,** Professor of Operations Research and Statistics (1962); B.S., Iowa State Univ., 1956; M.S., 1957; Ph.D., 1960.

**Peter Adrian Walter Lewis,** Professor of Operations Research and Statistics (1971); B.A., Columbia College, 1954; B.S., Columbia Engineering School, 1955; M.S., 1957; Ph.D., Univ. of London 1964.

**Glenn Frank Lindsay,** Associate Professor of Operations Research (1965); B.Sc., Oregon State Univ., 1960; M.Sc., Ohio State Univ., 1962; Ph.D., 1966.

**Kneale Thomas Marshall,** Professor of Operations Research (1968); B.Sc., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

**Alan Wayne McMasters**, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

**Paul Robert Milch,** Associate Professor of Operations Research and Statistics (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

**Douglas Elmer Neil,** Assistant Professor of Operations Research (1972); B.A., Univ. of Southern California, 1965; M.S., Univ. of Pacific, 1967; Ph.D., North Carolina State Univ., 1971.

**Samuel Howard Parry,** Associate Professor of Operations Research (1973); B.S., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

**Gary Kent Poock,** Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

**William Michael Raike,** Associate Professor of Operations Research (1971); B.A., Northwestern Univ., 1964; M.S., 1965; Ph.D., 1967.

**Robert Richard Read,** Professor of Operations Research, Probability and Statistics (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. of California at Berkeley, 1957.

**Francis Russell Richards,** Associate Professor of Operations Research (1970); B.S. Louisiana Polytechnic Institute, 1965; M.S., Clemson Univ., 1967; Ph.D., 1971.

**Ellen Franz Roland,** Lieutenant, U.S. Navy; Instructor in Operations Research (1978); B.S., Univ. of Wisconsin, 1972; M.S., Naval Postgraduate School, 1977.

**Bruno Otto Shubert,** Associate Professor of Operations Research, Probability and Statistics (1970); M.S., Czech. Technical Univ. at Prague, 1960; Ph.D. Charles Univ. at Prague, 1964; Ph.D., Stanford Univ., 1968.

**Rex Hawkins Shudde,** Associate Professor of Operations Research (1962); B.S., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California at Berkeley, 1956.

**James Grover Taylor**, Associate Professor of Operations Research (1968); B.S., Stanford Univ., 1961; M.S., 1962; Ph.D., 1966.

**Joseph Bryce Tysver**, Associate Professor of Operations Research and Statistics (1966); B.A., Washington State Univ., 1942; M.A., 1948; Ph.D., Univ. of Michigan, 1957.

**Alan Robert Washburn,** Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

**Peter William Zehna,** Professor of Operations Research and Statistics (1961); B.A., Colorado State College, 1950; M.A., 1951; M.A., Univ. of Kansas, 1956; Ph.D. Stanford Univ. 1959.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Operations Research.

## MASTER OF SCIENCE IN APPLIED SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in operations research at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Department of Operations Research. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

## MASTER OF SCIENCE IN OPERATIONS RESEARCH

1. A candidate shall previously have satisfied the requirements for the degree of Bachelor of Science in Operations Research or the equivalent.

2. Completion of a minimum of 48 quarter hours of graduate level courses, including at most 8 quarter hours for a thesis.

   a. At least 18 quarter hours of 4000 level operations research/ systems analysis courses.

   b. An elective sequence approved by the Department of Operations Research.

3. Submission of an acceptable thesis on a subject previously approved by the Department of Operations Research. This credit shall not count toward the requirement stated in 2a.

## DOCTOR OF PHILOSOPHY

1. Students currently enrolled in the Master of Science program and who wish to be considered for doctoral work in Operations Research should announce their intentions as early as possible, preferably by the fifth quarter. The department chairman will examine the applicant's qualifications, modify his second year program, and monitor his progress. The schoolwide requirements are contained in the General Information section of this catalogue.

2. Students wishing to enter directly into the doctoral program should write to the department chairman. Detailed admission procedures may

vary depending on the individual's location and position. However, in all cases the student must fulfill the schoolwidde requirements contained in the General Information section of this catalog.

3. If the applicant is selected, he must pursue a course of in-depth study in mathematical programming, stochastic processes and a third area approved by his doctoral committee. He must be advanced to candidacy and write an acceptable thesis pertinent to an area of specialization selected from the following four: stochastic processes, mathematical programming, decision sciences and human factors.

## OPERATIONS ANALYSIS

**OA 0001 Seminar for Operations Research/ Systems Analysis Students (0-2).**
Guest lecturers. Review of experience tours. Thesis and research presentations. PREREQUISITE: None.

**OA 0810 Thesis Research for Operations Research/Systems Analysis Students (0-0).**
Every student conducting thesis research will enroll in this course.

*Upper Division Courses*

**OA 2600 Introduction to Operations Research (2-0).**
A first course in Operations Research for students in the OA curriculum. Early origins of Operations Research and development through World War II to current practice. Introduction to fundamental concepts of the OR approach including the role of analytic models, decision variables, and measures of effectiveness. Model verification and interpretation of study results are discussed. PREREQUISITE: None.

**OA 2910 Selected Topics in Operations Research/Systems Analsysi (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in operations research.

*Upper Division or Graduate Courses*

**OA 3200 Computational Methods for Operations Research (3-2).**
Application programming for OR, Markov models, random sample generation, statistical data reduction; introduction to interactive modeling, CP/CMS, comparing interactive and batch methodologies, interactive data analysis. PREREQUISITE: CS 2600. Graded on Pass/Fail basis only.

**OA 3604 Linear Programming (4-0).**
Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, dual simplex algorithm, sensitivity analyses, parametric linear programming, transportation algorithm and matrix payoff games. Applications to resource allocation, manpower planning, transportation and communications network models, ship scheduling, and elementary strategic games. Introduction to machine computing and MPS. PREREQUISITE: MA 2042.

**OA 3605 Methods of Operations Research/ Systems Analysis (4-0).**
A course designed to survey the methodology of operations research and systems analysis. Topics in this sequence include: dynamic programming, PERT and PERT/COST, qeueing, reliability, maintenance, replacement, networks, stochastic models, and allocation of search. PREREQUISITE: OA 3604.

**OA 3620 Inventory I (4-0).**
A study of deterministic and approximate stochastic inventory models. Deterministic economic lot size models with infinite production rate, constraints, quantity discounts. An approximate lot size-reorder point model with stochastic demand. An approximate stochastic "order up to R" model. Single period stochastic models. Applications to Navy supply systems. PREREQUISITES: MA 2110, PS 3302.

**OA 3653 System Simulation (4-0).**
Computer simulation as a problem solving technique. Subject areas covered include: discrete event digital simulation methodology. Monte Carlo techniques, simulation programming in

FORTRAN and other available simulation languages, variance reduction techniques, design of simulation experiments and analysis of results. PREREQUISITES: CS 2600 or equivalent. PS 3303 or equivalent.

**OA 3654 War Gaming (3-2).**
Consideration of the problems inherent in the construction and use of manual and computer war games. Problems in the analysis of results of such games. PREREQUISITES: OA 3653, PS 3302. **Graded on Pass/Fail basis only.**

**OA 3656 Operations Research Problems in Special Warfare (4-0).**
The applicability of operations research to unconventional warfare and counterinsurgency. Normative and descriptive models. Consideration of special problems with emphasis on problem formulation. PREREQUISITES: OA 3604, PS 3303.

**OA 3657-3658 Human Factors in Systems Design I-II (4-0 to 3-0).**
The human element in man-machine systems. Selected topics in human engineering and psychophysics with emphasis on their relation to military systems. Man-machine interface and man's motor and sensory capacities. PREREQUISITES: PS 3303, OA 3604.

**OA 3660 Analysis of Operational Data (3-1).**
Analysis of real world operational data. The processing and interpretation of incomplete operational data. Problems will be chosen from current military problems. PREREQUISITES: PS 3303, OA 3653 (concurrently).

**OA 3704 Stochastic Models I (4-0).**
The primary goal of the course is to gain the theory necessary for stochastic modeling with Markov models. Particular topics include the homogenous and inhomogenous Poisson process, filter Poisson process, compound Poisson process, stationary Markov chains. The theory is augmented by examination and discussion of actual applications such as manpower management. PREREQUISITE: Basic probability with calculus as in PS 3302.

**OA 3900 Workshop in Operations Research/Systems Analysis (2-0 to 5-0).**
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. **Graded on Pass/Fail basis only.**

**OA 3910 Selected Topics in Operations Research/Systems Analysis (2-0 to 5-0).**
Presentation of wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research.

*Graduate Courses*

**OA 4322 Sample Inspection and Quality Assurance (4-0).**
Attribute and variables sampling plans. MIL.STD. sampling plans with modifications. Multi-level continuous sampling plans and sequential sampling plans. Structure of quality assurance programs and analysis of selected quality assurance problems. PREREQUISITE: PS 3303 or consent of Instructor.

**OA 4323 Decision Theory (3-0).**
Basic concepts, Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluations trials. PREREQUISITE: PS 3303.

**OA 4401 Manpower and Personnel Models (4-0).**
The objective of this course is to enable the student to make use of the major types of manpower and personnel models for estimating the effects of policy changes on the personnel system. Topics include longitudinal and cross-section models, optimization models, data requirements and validation. Applications in the form of current military models are included. PREREQUISITE: OS 3212 or OA 3604 and OA 3704.

**OA 4403 Industrial Engineering Requirements Determination (4-0).**
The objective is to enable the student to use some of the tools of industrial engineering in the determination of the quantity and quality of manpower required in military systems. Techniques include motion and time study, work sampling, predetermined time standards, work

design and layout, materials handling, procedures review and process design. Applications for ship and squadron manning documents and SHORESTAMPS are included. PREQUISITE: OS 3212 or OA 3604 and OA 3704.

OA 4614 Cost Estimation (4-0).
Advanced study in the methods and practice of systems analysis with emphasis on cost analysis; cost models and methods for total program structures and single projects; relationship of effectiveness models and measures to cost analyses; public capital budgeting of interrelated projects; detailed examples from current federal practices. PREREQUISITE: AS 3611, or equivalent.

OA 4615 Econometrics (4-0).
An introduction to the construction of testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavior. PREREQUISITES: PS 3303, AS 3610.

OA 4616 Defense Expenditure and Policy Analysis (4-0).
A presentation of the major components of defense budgeting and policy formulation from the standpoint of the three major institutions involved, the agency, executive and congress. The use of quantitative models of institutional behavior is emphasized when examining both individual institutions and the interaction between them. PREREQUISITE: AS 3611.

OA 4617 Campaign Analysis (4-0).
Study of the development, use, and state of the art of campaign analysis. Emphasis is placed on the different views of problem formulation and alternative approaches to campaign modeling so that the graduate will be able to improve campaign analyses. The structure of campaign analysis and the current spectrum of interaction assessment models used in campaign analysis are investigated. The students will study and discuss significant portions of actual campaign analyses such as SEA-MIX, Navy Fighter Study, etc. The classification requirement for the course is SECRET — NOFORN. PREREQUISITE: OA 3654.

OA 4621 Inventory II (4-0).
A study of stochastic inventory models. Single period models with time dependent costs, constrained multiple item single period models, deterministic and stochastic dynamic inventory models, deterministic and stochastic dynamic inventory models, the (r,R) periodic review model, the Q = 1 continuous review model, demand forecasting. PREREQUISITES: OA 3704, OA 3620.

OA 4622 Seminar in Supply Systems (4-0).
A survey of military supply systems, not only from an inventory point of view, but also as a critical area in logistics. Topics for discussion will be selected from the current literature and will be chosen according to student's interests. Periodically, experts in the supply field will provide guest lectures on current research areas. PREREQUISITES: OA 4621, OA 3704, or departmental approval.

OA 4631 Nonlinear and Dynamic Programming (4-0).
Introduction to modern optimization techniques and multistage decision processes. Kuhn-Tucker necessary and sufficient conditions for optimality, quadratic and separable programming, basic gradient search algorithms. SUMT penalty function method, dynamic programming. Applications to weapons assignment, force structuring, parameter estimation for nonlinear or constrained regression, personnel assignment and resource allocation. PREREQUISITE: OA 3604.

OA 4632 Mathematical Programming (4-0).
Advanced topics in linear programming. Large scale systems, the decomposition principle, additional algorithms, bounded variable techniques, linear fractional programming, probabilistic programming, formulation and solution procedures for problems in integer variables. Applications to the cutting stock problem, capital budgeting, large scale distribution systems, weapon systems allocations and others. PREREQUISITE: OA 3604.

OA 4633 Networks Flows and Graphs (4-0).
Survey of solution techniques for problems which can be related to problems involving flows in networks. Elements of graph theory, max-flow mincut theorem, shortest route problems, minimal cost flows, out-of-kilter

algorithm, CPM, PERT/Cost, and PERT/Time. PREREQUISITE: OA 3604.

**OA 4634 Games of Strategy (4-0).**
Mathematical models of conflict situations, emphasizing the theory of decision making against a completely opposed enemy. Applications to ASW, system acquisition, and other solutions to games that are partly cooperative. PREREQUISITE: A course in calculus and in probability.

**OA 4635 Nonlinear Programming (4-0).**
Continuation of OA 4631. Advanced topics in nonlinear programming including duality theory, further consideration of necessary and sufficient conditions for optimality, additional computational methods and examination of recent literature in nonlinear programming. PREREQUISITE: OA 4631.

**OA 4636 Dynamic Programming (4-0).**
A continuation of OA 4631. Basic theory of dynamic programming with numerous optimization and resource allocation applications in the areas of reliability design, target selection, inventory theory, project selection, and others. D.P. in Markov chains. PREREQUISITE: OA 4631.

**OA 4638 Optimization of Time-Sequential Processes (4-0).**
Study of time-sequential decision processes. Modelling and optimization of dynamic systems with one or more decision makers. Applications of modern optimal control theory and differential games to problems of military operations research. Typical areas of application are time-sequential combat games (air-war allocation strategies, fire-support allocation strategies), inventory systems, searching for targets, strategic missile allocations, pursuit and evasion, engagement of targets of opportunity. PREREQUISITE: OA 4631 or consent of the Instructor.

**OA 4642 Advanced Topics in War Gaming and Simulation (3-2).**
A greater-depth coverage of material introduced in OA 3653 and OA 3654. Advanced techniques of model development and simulation experimentation. Discussion of current research. Actual topics selected will depend on interests of students and instructor. This course is particularly appropriate for those doing theses in this area. PREREQUISITE: OA 3654 and Departmental approval.

**OA 4651 Search Theory and Detection (4-0).**
Seach and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths, lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search effort, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking, and trailing. PREREQUISITE: PS 3303 or equivalent.

**OA 4652 Operations Research Problems in Naval Warfare (3-0).**
Analyses of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and ASW. Current radar, sonar, communications, and ECM problems. PREREQUISITE: OA 4651.

**OA 4653 Operational Test and Evaluation (3-2).**
This course relates the theory and techniques of operations research to the problems associated with operational test and evaluation. Specific examples of exercise design, reconstruction, and analysis are examined. PREREQUISITES: OA 3660, OA 4651 or OA 4654.

**OA 4654 Combat Models (4-0).**
Introduction to the scientific study of warfare. Methodologies for the analysis and evaluation of military operations with emphasis on system effectiveness and measures of effectiveness. Study of models of combat processes (in particular, target acquisition and destruction). Introduction to Lanchester-type models of warfare and theory of duels. PREREQUISITE: OA 3704 or equivalent.

**OA 4655 Quantitative Analysis of Tactics (4-0).**
Applications of models of combat processes to the quantitative study of military tactics. Review of combat modelling theories. Class project of applying some quantitative methodology to a tactical problem of current interest. Advanced topics in Lanchester

theory of combat: variable attrition-rate coefficients, heterogeneous forces, breakpoints, secondary effects of casualties, suppressive effects. Mathematical models of tactical allocation. PREREQUISITE: OA 4654 or consent of the Instructor.

**OA 4656 Operations Research of Army Weapons Systems (4-0).**
The study of qualitative and quantitative methods applicable to the Army weapons system evaluation process. Topics covered are: the life cycle systems management model, army organization for operations research, operations research in the budgeting process, the cost and operational effectiveness analysi and the cost and training effectiveness analysis. The course includes a critical examination of combat models commonly used in systems effectiveness estimation. Existing analyses are reviewed through the case study method. PREREQUISITE: Departmental approval.

**OA 4756 Applications of Search, Detection and Localization Models to ASW (4-0).**
Applications of search, detection and localization models to search planning, target localization procedures, and ASW sensor evaluation. Both acoustic and nonacoustic sensors are considered. PREREQUISITES: OS 3651 or OA 4651. SECRET clearance and U.S. Citizenship.

**OA 4658 Tactical Design and Analysis (4-0).**
The use of hand-held programmable calculators (HPCs) and their application to tactical problems in the operational environment is the goal of this course. Characteristics of currently available HPCs will be discussed and compared; special emphasis will be placed on the use of their more sophisticated features. Methods for implementing environmental, search, localization, and tracking algorithms on the HPC will be discussed. Individual and/or group projects will allow the student to apply the concepts presented in class to problems in his area of expertise. PREREQUISITES: OA 4651, OS 3651 or consent of Instructor and SECRET NOFORN clearance.

**OA 4662 Reliability and Weapons System Effectiveness Measurement (4-0).**
Component and system reliability functions, and other descriptors for the reliability aspect of system effectiveness. Relationships between system and component reliability. Point and interval estimates of reliability parameters under various life testing plans. Illustrations of current methods of reliability assessment from appropriate MILSTD's and manuals. PREREQUISITE: OA 4705 (may be taken concurrently) or equivalent.

**OA 4680 Human Performance Evaluation (4-0).**
Experimental considerations, strategy, and techniques in evaluation of human performance characteristics and capabilities. Detailed examination of special methods to include multivariate designs, psychophysical methods, and psychophysiological methods. Review of important variable affecting human performance and criteria, measures of effectiveness, and figures of merit as indicants of performance quality. PREREQUISITE: OA 3657.

**OA 4685 Skilled Operator Performance (3-2).**
First part of the course is devoted to an examination of the theoretical foundations of skilled performance. The second half of the course is devoted to the study of the acquisition, development and prediction of skilled operator performance in the operational setting. PREREQUISITE: OA 3657.

**OA 4690 Evaluation of Human Factors Data (3-2).**
The course is primarily concerned with collection, evaluation, and analyses of data obtained from human subjects. Problem solving and extraction of results from actual human factors data is emphasized. Orientation of the course is toward applied solutions rather than theoretical education. PREREQUISITES: OA 3657, PS 3302, or equivalent.

**OA 4695 Operations Research in Man-Machine Systems (4-0).**
The course emphasizes the application of operations research techniques to man-machine system design and evaluation problems. Specific methodologies will be incorporated from mathematical programming, stochastic processes, decision theory, and other related areas. Quantiative methods for performance will be treated using

such concepts as reliability, information theory, and signal detection theory. A portion of the course will be devoted to summarizing approaches to real world problems incorporating current methods from the literature. PREREQUISITES: OA 3657, OA 3604, OA 3704, and OA 4705 (may be taken concurrently).

**OA 4705-4706 Stochastic Models II-III (3-2) and (4-0).**
Experience in stochastic modeling is gained by performance of a suitable project entailing data collection and analysis, formulation of model assumptions and application of the model to answer specific questions or help explain a particular phenomenon; study of non-Markovian systems. Queueing theory topics relevant to applications including deterministic queues, priority queueing systems with application such as cm computer time sharing, inequalities and approximations for general single served multichannel and tandom queue approximations, and heavy traffic queues with applications of the diffusion process. PREREQUISITE: OA 3704.

**OA 4910 Selected Topics in Operations Research/Systems Analysis (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research and Departmental approval.

**OA 4930 Readings in Operations Research/ Systems Analysis (2-0 to 5-0).**
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. **Graded on Pass/Fail basis only.**

## OTHER SERVICE COURSES

*Upper Division Course*

**OS 2201 Elements of Operations Research/ Systems Analysis (4-0).**
An introductory course. Topics covered include nature, origin, and contemporary status of operations analysis; problem formulation. PREREQUISITE: PS 2501 or equivalent.

*Upper Division or Graduate Courses*

**OS 3062 Intelligence Data Analysis (4-2).**
A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of intelligence data. Topics include sampling methods, content analysis, data handling and processing overview, scaling techniques, and parametric and nonparametric tests with emphasis on application. The student will be exposed to a wide spectrum of data relating to international problems, with particular emphasis on international commerce and trade, and national maritime capabilities. PREREQUISITES: PS 3000 or equivalent, CS 2100. **May also be offered as NS 3062.**

**OS 3203 Survey of Operations Analysis/ Systems Analysis (4-0).**
A survey of the military applications of operations analysis/systems analysis techniques of particular interest to the student. The applications usually covered are selected from decision, waiting lines, resource allocation, replacement, cost-effectiveness, inventory theory, and search models. The techniques needed for these applications are developed as required and usually include topics in linear programming (including the simplex method), probability theory, nonlinear programming statistics (including Bayesian and classical), dynamic programming and simulation. PREREQUISITE: PS 3211 or equivalent.

**OS 3205 Operations Research for Computer Scientists (4-0).**
An introduction to the methodology and techniques of operations research, with special emphasis on the computational aspects and on computer-related applications. Topics include linear programming, queueing theory, and PERT. Homework assignments include writing computer programs for some of the algorithms presented. PREREQUISITES: MA 2045, PS 3414 and CS 0110.

**OS 3206 Operations Research for Systems Acquisition (3-0).**
The analytical techniques of operations re-

search which are of use to the project manager in project planning and scheduling and in production planning and control. These techniques include scheduling (PERT/CPM), linear programming, inventory, theory, queueing theory and simulation, and quality assurance. PREREQUISITES: PS 3201 and PS 3202 or equivalent.

**OS 3207 Operations Analysis for Naval Intelligence (4-0).**
An introduction to the methodology and techniques of operations research, with special emphasis on specific areas relevant to naval intelligence such as decision-making under risk and uncertainty, forecasting, search, detection, resource allocation, and queues. PREREQUSITE: PS 3000 or equivalent.

**OS 3208 Operations Analysis for Electronic Warfare (4-0).**
This course deals with applications of quantitative models to operational electronic warfare problems, with the underlying idea being to make decisions by optimizing some measure of effectiveness (MOE). Topics covered include ESM, ECM/ECCM, strike warfare, ASMD, and cost-effectiveness tradeoffs. PREREQUISITES: Calculus, PS 3411 and OS 3653.

**OS 3210 Operations Research for Computer Systems Managers (4-0).**
A one-quarter survey of operations research techniques of particular interest to students in computer systems management. Model formulation, decision theory, linear programming, project management techniques, inventory models, queueing and simulation, reliability and maintainability. Examples will illustrate the application of these techniques to the management of computer systems. PREREQUISITES: MA 2300, PS 3011.

**OS 3211 Operations Research for Communications Managers (4-0).**
A one-quarter survey of operations research techniques of particular interest to students in communications management. Model formulation, decision theory, games, linear programming, network flows, CPM and PERT, reliablity and maintainability, queueing theory, and systems simulation. PREREQUISITES: MA 2300, PS 3000.

**OS 3212 Operations Research for Management (4-0).**
A survey of problem solving techniques for operations research. Topics include decision theory, linear programming, analysis of two-person games, Lanchester models of combat, project scheduling, inventory models, queueing models, and simulation. PREREQUISITES: MA 2300 and PS 3005.

**OS 3214 Operations Research Methodology (4-0).**
Survey of Operations Research techniques not covered in OS 3212. Topics may include simulation, search theory, extensions of combat models, network flows, and Markov chains. PREREQUISITES: PS 3211 and OS 3212 concurrently.

**OS 3215 Selected Topics in Management Science (2-0 to 5-0).**
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Department approval. Graded on Pass/Fail basis only.

**OS 3216 Analytical Planning Methodology (4-0).**
A one-quarter survey of operations research techniques of particular interest to students in the C3 curriculum, with emphasis on model formulation. Topics include linear and nonlinear programming, integer programming, networks, flow shop and project scheduling, decision analysis, queueing and simulation.

**OS 3306 Systems Effectiveness Concepts and Methods (4-0).**
An introduction to system reliability, maintainability, and effectiveness analysis. Failure (repair) rates and mean times to failure (repair). Models for aging and completion. Block diagrams and fault trees. Life testing. Availability, interval reliability, and the synthesis of reliability, maintainability, and effectiveness analysis. Failure (repair) rates and mean times to failure (repair). Models for aging and completion. Block diagrams and fault trees. Life testing. Availability, interval reliability, and the synthesis of reliability, maintainability, and effectiveness considerations. PREREQUISITES: OS 3202, OS 3203 (concurrently).

**OS 3322 Introduction to Quality Assurance (4-0).**

Characterization of quality requirements for materiel inspection procedures. Acceptance sampling, MilStd plans. Product and process quality cost analysis. Statistical control of quality. For students in management. PREREQUISITE: PS 3211 or OS 3202 or equivalent.

**OS 3390 Computation and Computer Simulation (4-2).**
Programming in FORTRAN and specialized simulation languages, with applications to the solution of ASW problems by simulation. Designed for students in ASW curriculum.

**OS 3651 Search, Detection, and Localization Models (4-0).**
An introduction to the decision problems associated with Navy detection systems. The relation of detection models to search and localization models, measures of effectiveness of search/detection systems, and the optimum allocation of search effort are discussed. The last week of the course requires participation in an ASW related group project. This course is designed for the ASW curriculum. PREREQUISITE: PS 3411 and SECRET clearance.

**OS 3652 Introduction to Combat Models and Weapons Effectiveness (4-1).**
This course deals with the application of quantitative models to military problems. Topics include Lanchester's theory, game theory, reliability theory, systems effectiveness, and war gaming. This course is designed for the ASW curriculum. PREREQUISITES: PS 3411 and MA 2129.

**OS 3653 System Simulation (4-1).**
Computer simulation as a problem solving technique. Subject areas covered include: Discrete event dignital simulation methodology, Monte Carlo techniques, simulation programming in FORTRAN and other available simulation languages, variance reduction techniques, design of simulation experiments and analysis of results. PREREQUISITES: CS 0110 or equivalent, PS 3411 or equivalent.

**OS 3655 Simulation and War Gaming (3-1).**
Design, implementation and use of digital simulation models will be covered with special emphasis on features common to C3 and EW problems. War gaming will be discussed and a game using the digital computer will be played and critiqued by the class. Exercise planning and analysis will be treated. Basic topics are explained including computer generation of random variates, statistical design and monitoring of model progress, machine representation of dynamic data structures, model verification and validation on special purpose simulation and gaming languages. PREREQUISITES: CS 2700, OS 3411, OS 3661 or equivalent.

**OS 3659 Human Factors Engineering (3-0).**
An introduction to human factors engineering for students in other fields such as engineering. Designed to give the student as appreciation of man's capacities and limitations and how these can affect the optimum design of the man-machine system. Emphasis on integration of human factors into the system development cycle considering such topics as manpower/personnel costs, control and display design, human energy expenditure, physiological costs, and evaluation systems. PREREQUISITE: A previous course in probability and statistics.

**OS 3661 Decision and Data Analysis (4-0).**
This course provides an introduction to the techniques of decision analysis, statistics and data analysis. It is primarily for students in the ASW, EW and C3 curricula. Emphasis is placed on the analysis of data and decision making in the ASW, EW and C3 environments. PREREQUISITES: PS 3411 or equivalent.

**OS 3665 Human Vigilance Performance (3-1).**
Course involves an examination of man's attentiveness and capability in the detection of changes in stimulus events over prolonged periods of observation. Topics to be covered include theories of vigilance; task, signal, subject and environmental influences on performance; physiological and psychological responses and vigilance performance measurement. This course is designed for the ASW curriculum. PREREQUISITE: OS 3661.

**OS 3670 Requirements Determination for C3 (4-0).**
The objective of this course is to enable the student to translate operational military requirements into functional capabilities of the system which can be directly addressed by the system engineers. Topics include military objectives, joint planning scenarios, joint military operations planning systems and their use in

determining C3 requirements. The dimensions of performance, availability, communications security, interoperability, vulnerability, survivability, technical risk, cost, frequency conservation and flexibility are examined. Requirements evaluation techniques such as systems analysis, cost effectiveness and the PPBS and DOD acquisition systems are presented. Examples are taken from recent experience. PREREQUISITES: CO 3111, OS 3216.

**OS 3671 Man-Machine Interaction (3-0).**
An introduction to the man-machine interface problems in C3. Information, display and human communication requirements for effective C3. Applied orientation with student receiving his own computerized mailbox on the ARPANET enabling him to experience message handling systems, network alerting systems, query languages, computer to computer communications between the U.S. and Europe, command and control applications programs, file transfer between host computers, etc. PREREQUISITE: None.

*Graduate Courses*

**OS 4063 Forecasting Threat Analysis and Net Assessment (4-0).**
A study of the intuitive, exploratory and normative forecasting methods, including brainstorming, Delphi, time series, scenario writing, uncertainty, cost benefit, input-output approaches. Conflict modelling; introduction of models of armament races and international conflict. Implications of such models for analyzing threats; search procedures for generating alternatives. Net assessment of such alternatives. PREREQUISITES: OS 3207, NS/OS 3062, NS 3420. May be also offered as NS 4063.

**OS 4207 Special Topics in the Analysis of Intelligence Problems (4-0).**
An examination of special intelligence problems and cases with emphasis on problem and project formulation, structure, and management as well as the interpretation and communication of study results. Applications of cost/benefit and input-output modelling to intelligence decision problems such as collection management, collection system design, data handling and manipulation. The last portion of the course will focus on student presentation of thesis research. PREREQUISITES: NS/OS 3062, OS 3207, NS/OS 4063. May also be offered as NS 4207.

**OS 4653 Operational Test and Evaluation (4-0).**
This course is designed for systems technology students. It deals with the problems associated with the tests and evaluations of military weapons systems, exercises and tactics. Included are concepts of the design of experiments; analysis of operational data; reliability; measures of effectiveness; and exercise design, reconstruction and analysis. Examples and case studies which involve ASW, EW, and AAW are examined. PREREQUISITE: OS 3661.

**OS 4703 Reliability, Maintainability, and Safety Analysis of Weapons Systems (4-0).**
Modeling and measurement of factors contributing to system effectiveness. Reliability. Maintainability. Safety. Life and repair distributions for components, block diagrams, and facult trees. Estimation for components and systems. Optimal redundancy and repair. PREREQUISITES: PS 3414, OS 3661, AS 2701.

## PROBABILITY AND STATISTICS

*Upper Division Course*

**PS 2350 Analysis of Experimental Data (3-1).**
Introduction to statistical analysis of measurements and experimental data. Frequency distributions, graphical representations. Populations and sampling. Principle of least squares, estimation of mean and standard deviation. Curve fitting and regression, propagation of errors. Confidence intervals, tests and contingency tables. Elementary ANOVA. Relevant probabilistic concepts introduced as needed. PREREQUISITE: None.

*Upper Division or Graduate Courses*

**PS 3005 Probability (3-0).**
A one-quarter course in probability. Random variables, probability axioms, independence, moments, derived distributions. Bayes Theorem, sampling, sample statistics. This course is designed primarily for students in management. PREREQUISITE: MA 2305 or equivalent.

PS 3011 Probability and Statistics for Management (5-0).
A treatment of selected topics in probability and statistics for management applications using elementary concepts from calculus; includes probability models, discrete and continuous random variables, some important distributions, sampling theory and an introduction to statistical inference. Includes inference for normal populations, estimation procedures, nonparametric procedures and linear models. PREREQUISITE: MA 2300 or equivalent.

PS 3201-3202 Fundamentals of Operations Analysis/Systems Analysis I-II (4-1).
Selected operations research techniques, primarily the elements of probability and statistics, applicable to the prediction of system cost, schedule, and effectiveness. Special topics in statistics, appropriate to applications in costing, quality assurance, and life testing. PREREQUISITE: Differential and integral calculus.

PS 3211 Statistics (4-0).
A survey of managerial statistics and decision analysis modeling. Topics include parameter estimation, confidence intervals, hypothesis testing, regression analysis. PREREQUISITES: MA 2300 and PS 3005 or their equivalents.

PS 3301 Probability (4-1).
Probability axioms and event probability. Random variables and their probability distributions. Moment generating functions, moments and other distribution characteristics. Distribution families characterized by parameters. Functions of a random variable. Chebychev inequality and law of large numbers. Probability integral transformation. PREREQUISITE: None. (May be taken through Continuing Education as the minicourse sequence PS 3851-54.)*

PS 3302 Probability and Statistics (4-1).
Jointly distributed random variables, independence and conditional distributions; correlation. Random samples. Derived distributions of functions of several random variables. Order statistics, the t and F distributions. Limiting distributions, the central limit theorem and approximations. Bivariate normal distribution; extension to the multivariate normal family. Point estimation; unbiasedness, maximum likelihood and Bayes. PREREQUISITE: PS 3301.

PS 3303 Statistics (4-1).
Interval estimation; confidence intervals and Bayesian intervals. Hypothesis testing. Regression and correlation analysis. Elements of the analysis of variance. Nonparametric inference. Applications to reliability, quality assurance, and operations analysis problems. PREREQUISITE: PS 3302.

PS 3411 Introduction to Applied Probability (4-0).
First course in probability for engineering students. Structure of a probability model, density, distribution function, expectation and variance. Some basic models, Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Transformations of random variables. PREREQUISITE: MA 1116 or equivalent.

PS 3412 Applied Stochastic Processes (4-0).
Stochastic process as a collection of random variables. Basic models, Binomial, Poisson and Wiener processes. Discrete and continuous parameter processes, stationarity and ergodicity. Correlation function and spectral representation. Gaussian processes, linear transformations, filtering and prediction. Markov processes, transient and steady-state behavior. Introduction to point processes. PREREQUISITE: PS 3411 or consent of Instructor.

**The minicourses are described in the Continuing Education catalog.*

PS 3413 Applied Statistics (3-1).
Basic ideas of statistical inference, random samples, Chisquare, t and F distributions. Point and interval estimation, properties. Linear mean-square estimation, Kalman filter. PREREQUISITE: PS 3411 or consent of Instructor.

PS 3670 Engineering Statistics (4-0).
Acquaint the engineering student with the techniques of statistical data analysis with examples from quality control, life testing, reliability and sampling inspection. Histograms and empirical distributions and random variables are introduced along with their

probability distributions and associated characteristics such as moments and percentiles. Following a brief introduction to decision making, standard tests of hypotheses and confidence intervals for both one and two parameter situations are treated. Regression analysis is related to least squares estimation and associated tests of hypotheses and confidence intervals treated. Additional techniques of data analysis using nonparametric procedures are developed. Quality control charts are discussed as applications along with sampling inspection by attributed and by variables. PREREQUISITE: Calculus.

*Graduate Courses*

**PS 4321 Design of Experiments (3-1).**
Theory of the general linear hypotheses. Analysis of variance. Planning of experiments. Simple factorial experiments. Randomized block and Latin squares. PREREQUISITE: OA 3303.

**PS 4431 Advanced Probability Theory (4-0).**
Definitions of a probability space, random variable, expectation and probability density. Modes of stochastic convergence. Characteristic functions and central limit theorems. Stable laws, infinite diversibility. Conditional expectations. PREREQUISITE: MA 3605 and/or departmental approval.

**PS 4432-4433 Stochastic Processes I-II (4-0).**
The Kolmogorov theorem; analytic properties of sample functions; continuity and differentiability in quadratic mean; stochastic integrals, stationary processes. Stationary and non-stationary problems; Martingale, limit theorems and the invariance principle. PREREQUISITE: PS 4431.

**PS 4434 Advanced Mathematical Statistics (3-0).**
The general inference problem, classical and Bayesian. Foundations of statistics from decision-theoretic viewpoint. Concepts of sufficient statistic, Fisher's and Kullback information. Theory of estimation and hypothesis testing. Sequential tests and empirical Bayes tests. PREREQUISITE: A basic course in probability and departmental approval.

**PS 4440 Time Series Analysis (4-0).**
Second order stationary processes. Harmonic analysis of correlation functions. Filters and spectral window. Ergodic properties. Problems of inference in time series analysis. Introduction to the analysis of multivariate processes. PREREQUISITE: Consent of Instructor.

**PS 4510 Selected Topics in Probability and Statistics (2-0 to 5-0).**
Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

# DEPARTMENT OF PHYSICS AND CHEMISTRY

*An experiment with the Iodine Laser.*

**Karlheinz Edgar Woehler,** Professor of Physics; Chairman (1962)* B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

**Robert Louis Armstead,** Associate Professor of Physics (1964); B.S., Univ. of Rochester, 1958; Ph.D., Univ. of California at Berkeley, 1964.

**Fred Ramon Buskirk,** Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

**Alfred William Madison Cooper,** Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's Uinv. of Belfast, 1961.

**John Niessink Cooper,** Professor of Physics (1956); B.A., Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

**Alan Berchard Coppens,** Associate Professor of Physics (1964); B. Eng. Phys., Cornell Univ., 1959; M.S. Brown Univ., 1962; Ph.D., 1965.

**Eugene Casson Crittenden, Jr.,** Distinguished Professor of Physics (1953); B.A., Cornell Univ., 1934; Ph.D., 1938.

**Harvey Arnold Dahl,** Assistant Professor of Physics (1964); B.S., Stanford Univ., 1951; Ph.D., 1963.

**John Norvell Dyer,** Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

**Harry Elias Handler,** Professor of Physics (1958); B.A., Univ. of California at Los Angeles, 1949; M.A., 1951; Ph.D., 1955.

**Don Edward Harrison, Jr.,** Professor of Physics (1961); B.S., College of William and Mary, 1949; M.S., Yale Univ., 1950; Ph.d., 1953.

**Otto Heinz,** Professor of Physics (1962); B.A. Univ. of California at Berkeley, 1948; Ph.d., 1954.

**Raymond Leroy Kelly,** Professor of Physics (1960); B.A., Univ. of Wichita, 1947; M.S., Univ. of Wisconsin, 1949; Ph.D., 1951.

**Herman Medwin,** Professor of Physics (1955); B.S., Worcester Polytechnic Institute, 1941; M.S. Univ. of California at Los Angeles, 1948; Ph.D., 1953.

**Edmund Alexander Milne,** Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S. California Institute of Technology, 1950; Ph.D., 1953.

**John Robert Neighbours,** Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D. 1953.

**Rainer Pitthan,** Assistant Professor of Physics (1973); B.S., Univ. of Marburg, 1962; M.S., Darmstadt Institute of Technology, 1967, Ph.D., 1972.

**William Reese,** Professor Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

**Richard Alan Reinhardt,** Professor of Chemistry (1954); B.S., Univ. of California at Berkeley, 1943; Ph.D., 1947.

**George Wayne Rodeback,** Associate Professor of Physics (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

**Charles Frederick Rowell,** Associate Professor of Chemistry (1962); B.S. Syracuse Univ., 1956; M.S., Iowa State Univ., 1959; Ph.D., Oregon State Univ., 1964; (on leave of absence)

**James Vincent Sanders,** Associate Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

**Gordon Everett Schacher,** Associate Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

**John Wilfred Schultz,** Associate Professor Chemistry (1958); B.S., Oregon State College, 1953; Ph.D., Brown Univ., 1957. (on leave of absence)

**Fred Richard Schwirzke,** Associate Professor of Physics (1967); B.S., Univ. of Rostock, 1950; M.S., Univ. of Karlsruhe, 1953; Ph.D., 1959.

**William Marshall Tolles,** Professor of Chemistry (1962); B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California at Berkeley, 1962.

**Oscar Bryan Wilson, Jr.,** Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A. Univ. of California at Los Angeles, 1948; Ph.D., 1951.

**William Bardwell Zeleny,** Associate Professor of Physics (1962); B.S., Univ. of Maryland, 1956; M.S. Syracuse Univ., 1958; Ph.D., 1960.

## EMERITUS FACULTY

**Newton Weber Buerger,** Professor Emeritus (1942); B.S., Massachusetts Institute of Technology, 1933; M.S., 1934; Ph.D., 1939.

**William Peyton Cunningham,** Distinguished Professor Emeritus (1946); B.S., Yale Univ., 1928; Ph.D., 1932.

**Austin Rogers Frey,** Distinguished Professor Emeritus (1946); B.S., Harvard Univ., 1930; M.S., 1924; Ph.D., 1929.

**William Wisner Hawes,** Professor Emeritus (1952); B.S., Ch. Eng., Purdue Univ., 1924; Sc.M., Brown Univ., 1927; Ph.D., 1930.

**Sydney Hobart Kalmbach,** Professor Emeritus (1947); B.S., Marquette Univ., 1934; M.S., 1937.

**Gilbert Ford Kinney,** Distinguished Professor Emeritus (1942); A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

**George Daniel Marshall, Jr.,** Professor Emeritus (1946); B.S., Yale Univ., 1930; M.S., 1932.

**George Harold McFarlin,** Professor Emeritus (1948); B.A., Indiana Univ., 1925; M.A., 1926.

**Leonard Oliver Olsen,** Professor Emeritus (1960); B.A., Iowa State Teachers College, 1932; M.S., State Univ. of Iowa, 1934; Ph.D., 1937.

**Melvin Ferguson Reynolds,** Professor Emeritus (1949); B.S., Franklin and Marshall College, 1932; M.S., New York Univ., 1935; Ph.D., 1937.

**John Dewitt Riggin,** Professor Emeritus (1946); B.S., Univ. of Mississippi, 1934; M.S., 1936.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

## DEGREE REQUIREMENTS

The Department of Physics and Chemistry offers the MS and BS degrees in Physics, in Chemistry and in Applied Science. In addition, the Ph.D., is offered by the Department. Upon approval by the Department, courses taken at other institutions may be applied towards satisfying degree requirements.

## MASTER OF SCIENCE IN PHYSICS

1. A candidate for the degree Master of Science in Physics must complete satisfactorily a program of study which includes a minimum of 30 quarter hours of physics courses (not including thesis) distributed among courses at the graduate level; of this 30 hours at least 15 hours must be at the 4000 level. Upon approval of the Chairman of the Physics and Chemistry Department a maximum of 4 hours of courses taken in another department may be applied toward satisfying the above requirements. In lieu of the preceding requirement, students who are qualified to pursue graduate courses in physics when they arrive at the Postgraduate School may complete a minimum of 20 hours entirely of 4000 level physics courses. In addition, all students must present an acceptable thesis.

2. The following specific course requirements must be successfully completed for a student to earn the degree of Master of Science in Physics:

a. Thermodynamics and Statistical Mechanics — the student must take a two-quarter sequence or present equivalent preparation in this area.

b. A course in Advanced Mechanics or Quantum Mechanics.

c. A course in Electromagnetism at the 4000 level.

d. An advanced course in Modern Physics.

e. Specialization, to include at least two advanced courses in an area of specialization.

3. Programs leading to the Master of Science degree in Physics must

be approved by the Chairman of the Department of Physics and Chemistry.

### MASTER OF SCIENCE IN APPLIED SCIENCE

A candidate for the degree Master of Science in Applied Science must complete satisfactorily a program of study which includes 20 quarter hours of courses in physics and/or chemistry at the graduate level including work at the 4000 level; a departmentally approved sequence containing a minimum of 12 hours at the graduate level which is taken outside the Department of Physics and Chemistry; of the above 32 quarter hours of work at the graduate level at least 12 must be in 4000 level courses. The candidate must present an acceptable thesis on a topic given prior approval by the Department of Physics and Chemistry. Final approval of all programs leading to the Master of Science in Applied Science shall be obtained from the Chairman of the Department of Physics and Chemistry.

### DOCTOR OF PHILOSOPHY

The Ph.D. degree is offered in the Department in several areas of specialization which currently include Acoustics, Atomic Physics, Solid State Physics, Theoretical Physics, Nuclear Physics and Plasma Physics.

Requirements for the degree may be grouped into 3 categories: courses, thesis research and examinations in major and minor fields and languages.

The required examinations are described elsewhere in this catalog in the section Requirements for the Doctor's Degree. In addition to the school requirements the department requires a preliminary examiniation to show evidence of acceptability as a doctoral student.

The usual courses to be taken by the candidate include Advanced Mechanics, Classical Electrodynamics, Quantum Mechanics and Statistical Physics. ( PH 4171, 4371, 4971,4972, 4973, 4571, 4572). Suitable electives are to be chosen in physics and the minor fields, mainly from the list of graduate level courses.

### PHYSICS AND CHEMISTRY LABORATORIES

The physics laboratories are equipped to carry on instructional and research work in nuclear physics, solid state physics, electro-optics, plasma physics, spectroscopy, and acoustics.

A 100-Me V electron linear accelerator with 5-microamp beam current is used in nuclear physics research as well as radiation effects studies. A 2-Me V Van de Graaff accelerator is also available for nuclear and atomic physics work.

The electro-optics laboratory uses imaging and detecting systems from the far infrared to the visible range including instrumentation for seagoing experiments in optical propagation. The laser laboratory contains a giant pulse laser and associated detection equipment for the visible spectrum as well as a high power laser in the IR region.

The plasma physics laboratory includes a plasma system, diagnostic equipment for studies of plasma dynamics, and a steady state plasma source with magnetic fields to 10,000 gauss.

The spectroscopy equipment includes a large grating spectrography, a large prism spectrograph,

and an infrared spectrophotometer. The spectroscopic data center contains a comprehensive compilation of the known energy levels and atomic spectral lines in the vacuum ultraviolet range.

The acoustics laboratory equipment includes a large anechoic chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics. Sonar equipment, test and wave tanks, and instrumentation for investigation in underwater sound comprise the underwater acoustics laboratory.

The chemical laboratories provide facilities for undergraduate and graduate study and research in chemistry. Supporting these activities are: a molecular spectroscopy laboratory, including infrared, ultraviolet, and magnetic resonance (ESR and NMR) spectrometers; a chemical instruments laboratory with infrared and ultraviolet spectrophotometers, an atomic absorption spectrophotometer, gas and liquid chromatographic equipment, and a vapor-phase osmometer; and a chemical dynamics laboratory with equipment for investigating photochemistry, rapid reaction kinetics, and chemical synthesis.

## PHYSICS

PH 0110 Refresher Physics (5-3).
A six-week course designed to refresh incoming students, particularly allied Officers, in selected basic concepts of mechanics. The level of presentation and choice of material depend upon the background and needs of the students. The laboratory sessions are used to develop problem solving skills. Noncredit.

PH 0111 Refresher Physics and Chemistry (7-3).
A six-week refresher course of selected topics from elementary mechanics and chemistry for incoming students who are entering the more quantitative engineering and science curricula. Typical topics from mechanics are kinematics, Newton's laws, the concepts of energy, and momentum, and simple harmonic motion. Chemistry topics will include atomic structure, the chemical bond, stoichiometry, and chemical equilibrium and kinetics. The use of calculus and vector algebra is emphasized. The three one-hour laboratory periods are devoted to guided problem solving. PREREQUISITE: Previous college courses in elementary physics and chemistry and integral calculus.

PH 0499 Acoustics Colloquium (0-1).
Reports on current research and study of recent research literature in conjunction with the student thesis. PREREQUISITE: A course in acoustics.

PH 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

PH 0999 Physics and Chemistry Colloquium (0-1).
Discussion of topics of current interest and student thesis reports.

### *Lower Division Courses*

*The BASIC PHYSICS sequence, PH 1011, PH 1012, PH 1013, and PH 1014, comprises a series of courses equivalent to the standard university level introductory physics courses with calculus. Normally the student is expected to have adequate preparation in these areas at the time of matriculation at NPS; however these courses are available upon demand for students with partial or no background in basic physics.*

The minicourses Ph 1061 through PH 1067 comprise a Basic Physics sequence available in the self-instructional (PSI) mode for both on-campus and off-campus use.* Various combinations of these mini-

courses are essentially equivalent to, and may be substituted for, the courses PH 1011, PH 1012, PH 1041, and PH 1051, as follows:

| "classroom" courses | equivalent PSI sequence |
|---|---|
| PH 1011 | PH 1061, PH 1062, PH 1063 |
| PH 1012 | PH 1064, PH 1065, PH 1066 |
| PH 1041 | PH 1061, PH 1062, PH 1064, PH 1065 PH 1066 |
| PH 1051 | PH 1061, PH 1062, PH 1063, PH 1067 |

*The minicourses are described in the Continuing Education catalog.*

*BASIC PHYSICS LABS. Students requiring laboratory experience at this level should examine the course descriptions of PH 1300, which would normally be taken concurrently with PH 1012; PH 1400, which would normally be taken concurrently with PH 1013; and PH 1600, which would normally be taken concurrently with PH 1014.*

PH 1011 Basic Physics I — Mechanics (4-0).
Vector algebra, particle kinematics in one and two dimensions; Newton's Laws; particle dynamics; work, kinetic and potential energy, conservation of energy; conservation of linear momentum; rotational kinematics and dynamics, conservation of angular momentum; oscillations; gravitation. PREREQUISITE: A course in calculus or concurrent registration in a calculus course.

PH 1012 Basic Physics II — Electricity and Magnetism (4-0).
Electric charge, Coulomb's Law, Electric Field and Potential, Gauss's Law, Capacitors and Dielectrics, Current and Resistance, Simple Circuits, EMF, Magnetic Field, Ampere's and Faraday's Laws, Inductance, Electromagnetic Oscillations and Waves. Maxwell's Equations. PREREQUISITE: PH 1011 or equivalent.

PH 1013 Basic Physics II — Fluids, Waves and Thermodynamics (4-0).
Fluid states, conservation of matter, fluid dynamics, Bernoulli Equation; waves, sound waves, sonar equation; temperature, heat, internal energy, First Law of Thermodynamics; kinetic theory; entropy and second law of thermodynamics. PREREQUISITE: PH 1011, or equivalent. (PH 1012 is not a prerequisite for this course).

PH 1014 Basic Physics IV — Optics, Atomic and Nuclear Physics (4-0).
Reflection and refraction; lenses and lens systems; optical devices; interference, diffraction; special relativity; quantum effects of waves and particles; structure of the hydrogen atom, introduction to wave mechanics, uncertainty principles nuclear structure and nuclear reactions. PREREQUISITE: PH 1011 and PH 1012, or equivalent.

PH 1041 Review of Mechanics and Electricity and Magnetism (5-1).
A review course designed to serve students in Electrical Engineering. The subject matter of this course includes: kinematics, dynamics, conservation laws, electrostatics, Coulomb's and Gauss's laws, electric and magnetic fields, Ampere's and Faraday's laws, capacitance and inductance. PREREQUISITE: Previous course in general physics and calculus.

PH 1051 Review of Vector Mechanics and Introduction to Fluids (4-2).
Basic concepts of elementary vector mechanics, including; statics, motion in one dimension and in a plane, particle dynamics, energy, momentum, rotational dynamics, elementary properties of fluids, qualitative description of drag phenomena; turbulence and separation. The laboratory sessions are devoted to guided problem-solving. PREREQUISITE: Previous courses in general physics and calculus.

PH 1119 Oscillations and Waves (2-1).
A course of six weeks duration designed for the Antisubmarine Warfare curriculum. The course includes the use of coordinate systems and vectors, kinematics and dynamics, work and energy, the harmonic oscillator, resonance, and an introduction to wave motion.

**PH 1300 Basic Electricity and Magnetism Laboratory (0-2).**
An introductory laboratory for students who have had no previous experience with the fundamental experiments of electricity and magnetism. PREREQUISITE: Concurrent registration in PH 1012 desirable.

**PH 1400 Basic Fluids and Waves Laboratory (0-2).**
An introductory laboratory for students who have had no previous experience with the fundamental experiments of fluid dynamics, wave motion, and acoustics. PREREQUISITE: Concurrent registration in PH 1013 desirable.

**PH 1600 Basic Modern Physics Laboratory (0-2).**
An introductory laboratory for students who have had no previous experience with the fundamental experiments of modern physics. PREREQUISITES: PH 1300, concurrent registration in PH 1014 desirable.

**PH 1901-1902 The Nature and Structure of Physics I-II (4-2).**
The development of ideas and measurement leading from early models of the heavens through Galileo and Kepler to Newton and the Theory of Universal gravitation; satellites, natural and artificial; the concepts central to classical mechanics: momentum, kinetic and potential energies, conservation principles; questions about the nature of light; wave motion and wave properties of light. Fundamental concepts of electromagnetism and light as electromagnetic radiation; experiments with light and the crisis of classical physics; Einstein and Relativity; space and time revised, mass-energy equivalence; the question of atomic structure and the quantum interpretation; properties of atoms, nuclei, and particles.

*Upper Division Courses*

**PH 2123 Basic Physics (4-0).**
A course to provide physical background to wave motion, acoustics, electromagnetism, and optics for students in the Electronic Warfare curriculum and to provide applications of analytical techniques to physical problems. Areas covered are harmonic motion — differential equations, complex notation, damped vibration and resonance; wave motion — properties of waves, sound waves; electromagnetism — electrostatics, magnetostatics, electromagnetic waves, light; optics — geometrical optics, wave optics. PREREQUISITES: MA 2129, MA 3139 (may be concurrent).

**PH 2151 Mechanics I — Particle Mechanics (4-1).**
After a review of the fundamental concepts of kinematics and dynamics this course concentrates on those two areas of dynamics of simple bodies which are most relevant to applications in Weapon Systems Engineering: vibrations and projectile motion. Topics are: oscillatory motion of single masses under the influence of friction forces and various types of driving forces, the phenomenon of resonances and nonlinear oscillations. After an introduction to the principle of inertial reference frames an in depth study of projectile motion is made. This includes ballistic trajectories with and without atmospheric friction, satelite orbits and their stability.

**PH 2241 Wave Phenomena (4-0).**
Second quarter of a sequence of fundamental physics for students in Electrical Engineering and Electronics. This course stresses the generality of wave phenomena drawing examples from optics, radar, acoustics, etc. Harmonic waves, interference, diffraction, wave equation, energy flow, boundary value problems and normal modes. Fourier analysis, Fourier transform phase and group velocity, geometrical optics. PREREQUISITES: PH 1041 or PH 1051.

**PH 2251 Physical Optics and Introductory Modern Physics (4-2).**
A course designed to provide the fundamental ideas of wave theory, physical optics, and introductory modern physics. Topics covered include the wave equation, phase and group velocity, Fresnel's equations, Fourier transforms, interference, diffraction, polarization, birefringence, black-body radiation, special theory of relativity, the photon, photoelectric effect and Compton scattering, Bohr atom, de Broglie hypothesis, Schroedinger equation, infinite and finite square well. A laboratory is included. (May be taken through Continuing Education as the minicourse sequence PH 2253-55.)*

**PH 2260 Optical Physics (4-2).**
Wave and ray optics, optical instruments, wave propagation, interference, coherence, diffraction, polarization, and radiation sources. Laboratory: The laboratory sessions will be devoted to student performance of exercises designed to complement class discussions and to develop skills with optical instrumentation. PREREQUISITES: PH 1051, MA 1100 or equivalents.

**PH 2265 Geometrical Optics (2-2).**
The course first introduces geometrical optics; reflection and refraction of rays at plane and spherical surfaces; mirrors, plane and spherical; lenses, thick lenses and lens aberration; matrix methods for thick lenses and lens systems. A laboratory is included. Subjects to be covered include laboratory procedures, definition of measurement, random and systematic errors, propagation of uncertainties, graphical and analytical treatment of data, statistical concepts, focal length of lens and mirror, refractive index of glass, thick lens, optical instruments, optical spectra, the prism spectrometer. PREREQUISITE: A course in basic physics.

**PH 2270 Fundamentals of Electro-Optics (4-0).**
This course is designed to provide specific background material needed for an understanding of electro-optics. This material is in the general areas of advanced optics, atomic physics, solid state physics, and lasers. In more detail, the areas are catadioptric systems, matrix optics, gaussian profile beams, Fourier optics, resolution, atmospheric transmission, atomic and molecular energy states, line shapes, electrons in solids, band theory, photoconduction, p-n junction photocells, light emitting diodes, optical materials, stimulated emission, laser pumping, laser types, high energy lasers. PREREQUISITES: MA 3139, PH 2123 (or equivalent).

**PH 2351-2352 Electromagnetism I-II (4-1) and (4-0).**
Properties of electric and magnetic fields and the development of Maxwell's Equations (for static fields); electrostatic fields and potential in free space and dielectrics, the magnetic fields and potentials of steady currents in free space and permeable materials, electromagnetic induction, Maxwell's Equations, and Poynting's Theorem. Faraday's law and the general Maxwell equations; properties of electromagnetic waves: wave equations; propagation of plane waves in free space, dielectrics, conductors, and plasmas; reflection and refraction of plane waves; two-conductor transmission lines; rectangular wave guides. A condensed version of this course, with emphasis on wave propagation is available as PH 3360. PREREQUISITES: PH 1051 and MA 2161 or equivalent.

**PH 2471 Introduction to the Sonar Equations (3-0).**
A discussion of each term of the solar equation with application to the detection, localization, and classification of underwater vehicles. This course is intended primarily for the students in the Antisubmarine Warfare curriculum. PREREQUISITES: Precalculus mathematics. **(May be taken through Continuing Education as the minicourse sequence PH 2474-76.)***

**The minicourses are described in the Continuing Education catalog.*

**PH 2552 Introduction to the Thermal and Dynamic Properties of Gases and Lquids (3-0).**
Introductory thermodynamics including the First and Second Laws, properties of gases and liquids, basic fluid mechanics including equations of motion in both inertial and non-inertial coordinate systems. This course is designed for the ASW curriculum. PREREQUISITES: Courses in vector calculus and differential equations (may be taken concurrently).

**PH 2641 Atomic Physics (4-2).**
Third quarter in the sequence of fundamental physics for students in Electrical Engineering and Electronics. Bohr model. Schroedinger equation, exact solution for hydrogen atom, electron spin, periodic table, atomic spectra, transition probabilities, Einstein coefficients and stimulated emission, molecules and molecular spectra. PREREQUISITES: PH 2241 and PH 2251.

**PH 2810 Survey of Nuclear Physics (4-0).**
An introduction to the basic concepts of nuclear

physics with emphasis on neutron physics and nuclear reactors. Atomic nature of matter, wave-particle duality, energy levels. Basic nuclear properties, radioactivity, neutron reactions. Elements of fission and fusion reactors.

**PH 2903 Physics and Modern Devices (3-2).**
Development of the physical foundations of some recent technological devices of interest to the Naval Officer. The topics will be selected according to the interests of the class and instructor and could include items such as lasers, magnetometers, underwater detection, nuclear fission and fusion, solid state electronics. PREREQUISITE: PH 1902 or consent of the Instructor.

*Upper Division or Graduate Courses*

**PH 3152 Mechanics II — Extended Systems (4-0).**
The principles of dynamics are applied to real extended bodies. Topics of application are: principles of rocket propulsion, impact of rigid bodies on other bodies, rotational motion of axisymmetric bodies and its application in projectile spin and gyroscopic motion. An introduction to generalized methods of description of dynamic systems is given and the general behavior of complex vibrating systems is studied. PREREQUISITE: PH 2151.

**PH 3154 Physics of Space Vehicle Dynamics (3-0).**
Basic physical principles are applied to study the trajectories of satellites and missiles: orbits in the inverse-square force field are developed, including the role of initial (launch) conditions, followed by rendezvous problems, transfer between orbits, synchronous satellites, perturbations due to oblateness of the earth. An introduction to launch and re-entry problems is given, including multistage rockets. Advanced propulsion methods. PREREQUISITES: PH 3152 or equivalent mechanics course.

**PH 3157 Physics of Continua (4-0).**
The continuum hypothesis. Cartesian tensors. The concept of stress. Deformation. Conservation of mass, momentum and energy. Theory of constitutive equations. Applications to fluid mechanics, solid mechanics and wave phenomena. PREREQUISITE: PH 2151.

**PH 3161 Fluid Dynamics (4-1).**
The course emphasizes the dynamics of real fluids both compressible and incompressible and their mathematical descriptions with the methods of vector calculus. After an introduction into basic fluid characteristics the concepts of fluid kinematics, transport, stress, strain, conservation laws, stress-strain relations and the Navier Stokes equation of fluid dynamics are developed. These principles are then applied to incompressible flow, potential flow, compressible subsonic and supersonic nozzle flow, laws of similarity and the significance of Froud, Reynold and Machnumber, Laminar vs turbulent flow, boundary layers, drag and lift. Dependent on student's needs special topics on dynamics of underwater vehicles, ship resistance, drag reduction, flow noise or applications to internal ballistics and missile dynamics may be included. PREREQUISITE: PH 2151 or equivalent.

**PH 3271 Electro-Optic Principles and Devices (4-0).**
This course is designed to provide the student with an understanding of the principles of operation of the components that make up electro-optic systems. The general areas to be included are atmospheric transmission, nonlinear optics, detectors and displays. All wavelength ranges in which the atmosphere transmits will be treated, from ultraviolet to the far infrared. In more detail, the material will include thermal blooming, adaptive optics, EO signatures, EO modulators and shutters, beam steerers, detectors, cooling, imaging detectors for low light level TV and FLIR, CCD's and CID's image storage and display. PREREQUISITES: PH 2270, MR 2416.

**PH 3280 Electro-Optics (4-2).**
Refracting systems; atmospheric and underwater transmission, scattering, and scintillation; diffraction and Fourier transform methods; coherent optics. Fourier plane filters, holography; fiber and film optics; electroptic detectors; infrared techniques; image intensifiers; lasers and applications; nonlinear optics. PREREQUISITES: PH 2265, PH 2251 or equivalent.

**PH 3281 Non-Acoustic Sensor Systems (4-0).**
A course for the ASW curriculum. The purpose is to expose the technology and engineering of

various systems important in antisubmarine warfare operations which involve non-acoustic sensing methods. Systems to be discussed include passive and active electronic warfare. Echo ranging, field distortion, image systems, communications and telemetry, proposed systems. The systems approach implies a consideration of environmental effects. PREREQUISITES: EE 2721, PH 3360, EE 3714, SECRET clearance.

PH 3321 Radiation Systems (4-0).
This course for students of Operations Research and other Weapon System oriented non-engineering curricula discusses the physical principles exploited by information-gathering systems with emphasis on general capabilities and limitations. After a general introduction to wave propagation topics of discussion are electromagnetic waves, radar, electro-optics including lasers, and underwater sound. These topics will be applied to specific systems such as missile guidance, sonobouys, and phased arrays, as appropriate to the class and instructor. PREREQUISITES: MA 1116 or equivalent may be taken concurrently, or by consent of the Instructor.

PH 3360 Electromagnetic Wave Propagation (4-1).
After an analytical introduction to electromagnetic field theory, the course concentrates on properties of electromagnetic wave propagation and the phenomena of radio and radar transmission, including special topics on antennas and waveguides. PREREQUISITES: MA 3139, a course in general physics, and an introduction to vector analysis.

PH 3431 Physics of sound in the Ocean (4-2).
A survey of physical acoustics with emphasis on the generation, propagation, and detection of sound in the ocean, primarily for students in the Environmental Science and Operations Analysis Curricula. Topics include: damped and forced harmonic oscillations; the acoustic wave equation and its limitation in fluids; solutions for plane and diverging waves; ray acoustics; radiation of sound; reflection from boundaries; normal mode propagation in the ocean; effects of inhomogeneties and sound absorption; term by term analysis of the SONAR equations emphasizing transmission loss models and detection threshold models; properties of transducers for underwater sound. Laboratory experiments include surface interference, spectral analysis of noise, normal modes, waveguides, and acoustical sources. PREREQUISITES: A course in general physics and a course in differential equations and complex exponential notation.

PH 3451 Fundamental Acoustics (4-1).
Mechanics of free, forced, and damped simple vibratory systems. Mechanical impedance. Development of, and solutions to the acoustic wave equations in extended media. Propagation of plane waves in fluids and between media. Acoustical behavior of sources and arrays. Radiation impedance. Introduction to transducers. Laboratory experiments on selected topics. PREREQUISITES: A course in mechanics (e.g., PH 1051?; differential equations (e.g., MA 2121).

PH 3452 Underwater Acoustics (4-2).
Lumped acoustic elements and propagation in pipes. Steady state response of acoustic waveguides. Group and phase speeds. Normal modes. Sound absorption and dispersion for classical and relaxing fluids. Transmission of sound in the ocean; the eikonal equation and necessary conditions for ray acoustics, method of images, refraction and ray diagrams, mode propagation in shallow water and refraction channels. Ambient noise and reverberation. Target strength. The sonar equations for active and passive systems. Laboratory experiments on selected concepts. PREREQUISITE: PH 3451.

PH 3458 Noise, Shock and Vibration Control (4-0).
The application of the principles of acoustics and mechanics to the problems of controlling noise, vibration and mechanical shock. Topics include: Linear mechanical vibrations, introduction to vibrations of non-linear systems; damping mechanisms; vibration and shock isolation; noise generation and control; effects of noise on man; application to problems of Naval interest such as ship quieting and industrial noise control. PREREQUISITE: A course in acoustics.

PH 3461 Explosive Shock Waves (4-0).

Generation and propagation of explosive shock waves in air and water including Rankine-Hugoniot equations, scaling laws, reflection and refraction phenomena, and experimental data. Damage mechanism and principles of protection against damage. PREREQUISITES: PH 2551 or CH 2401, and PH 2151 or PH 3451.

**PH 3463 Special Topics in Underwater Acoustics and Sound (3-2).**
Special topics of interest in the areas of underwater sound, transduction, propagation and detection, depending on the interests and needs of the students. PREREQUISITE: A course in acoustics, i.e.; PH 3431, 3451, or 3452.

**PH 3472 Underwater Acoustics (4-2).**
In this course, the second of a three-course sequence for students in the ASW curriculum, an analytical study is made of the underwater acoustics that affect the sonar equation. Topics include: the wave equation and ray acoustics; acoustic properties of fluids; plane, spherical, and cylindrical waves; behavior of sources and arrays; reflection and transmission at boundaries; image theory; propagation in wave guides; and normal mode propagation in the ocean. This course is taugth in coordination with OC 3265. PREREQUISITES: PH 3471 and concurrent enrollment in OC 3265.

**PH 3551 Thermodynamics (4-1).**
Fundamental theory of thermodynamics and applications to physical systems. First and second laws of thermodynamics; entropy; thermodynamic potential; applications to gases, liquids, radiation, and magnetic materials; equilibrium. PREREQUISITES: PH 1051 and calculus of several varibles.

**PH 3561 Introductory Statistical Physics (4-0).**
Distribution functions, kinetic theory, transport processes, introduction to classical and quantum distributions. Applications to gases, solids, and radiation. PREREQUISITES: PH 2152, PH 2551, or CH 2401, PH 3651.

**PH 3651 Atomic Physics (4-2).**
The Schroedinger equation. Free states, barrier penetration, the square well and the hydrogen atom. Electron Spin. The exclusion principle and the periodic table. Multi-electron atoms, the vector model, coupling schemes. Zeeman effect. Transitions. The Kronig-Penny model and band theory of solids. Semiconductors. There is a lab included. PREREQUISITES: PH 2251 and MA 2161 or equivalent.

**PH 3652 Molecular and Solid State Physics (4-0).**
Applications of Atomic theory to molecular and solid state physics. Molecular binding and energy levels. Crystals, their classification and properties. Brillouin Zones and the Fermi Surface. Semiconductors and solid state electronics applications to photovoltar cells, LED's and lasers. Other applications as may be timely. PREREQUISITE: PH 3651.

**PH 3687 Physics of Electron Interaction in Gases (3-0).**
This course stresses the basic electronic processes in gases, fundamental to the physics and chemistry of the upper atmosphere and to the operation of electron devices including the gas laser. Topics covered include elastic collisions, free and ambipolar diffusion, mobility, excitation and ionization, charge transfer emission from surfaces, recombination high frequency d c and laser breakdown, sheaths, the glow and arc discharges, radiation, application to the gas laser. PREREQUISITES: PH 2641 or PH 3651 or consent of the Instructor.

**PH 3741 Electronic Properties of Metals and Semiconductors (4-2).**
Fourth course in the sequence of fundamental physics of students in Electrical Engineering an Electronics. (PH 1041, PH 2241, PH 2641) Crystals and lattice properties, X-ray diffraction, free-elective mass, holes, intrinsic and impurity semiconductors, diodes, transistors, thermoelectric effects, minority carriers, modern devices. PREREQUISITES: PH 2641 or PH 3651.

**PH 3900 Advanced Physics Laboratory (0-3).**
This laboratory course provides entry into specialty areas of experimental physics. Experiments will be conducted as projects assigned on an individual basis in such areas as modern optics, electro-optics, electron resonance, plasma physics, nuclear physics and properties of solids. Modern experimental techniques will be stressed. PREREQUISITES: Consent of Department Chairman.

**PH 3951 Quantum Mechanics (4-0).**

Applications of quantum mechanics to phenomena in atomic, molecular, and solid-state physics, angular momentum. Spin states of hydrogen Spin-orbit coupling and Zeeman effect. Variation methods and perturbation theory. Electronic structure of atoms and molecules. Molecular and chemical lasers. Molecular vibrations and rotations. Raman effect. Group theory. PREREQUISITE: PH 3651.

**PH 3998 Special Topics in Intermediate Physics (1-0 to 4-0).**
Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interest of students. The course may be conducted as seminar or supervised reading. It carries a letter grade and may be repeated in different topics. The course may also be taken on the pass/fail basis provided the student has requested so at the time of enrollment. PREREQUISITE: Consent of the Department Chairman.

*Graduate Courses*

**PH 4162 Fluid Mechanics (3-0).**
An advanced study of the physical bases of fluid mechanics: Fundamental concepts of continuum mechanics. Fluid mechanical models. Theory of hydrodynamic stability. Lighthill's theory of aerodynamically produced sound. Effects of compressibility. PREREQUISITE: A course in hydrodynamics (e.g., PH 3161).

**PH 4171 Advanced Mechanics (4-0).**
Hamilton's Principle. The equations of motion in Lagrangian and Hamiltonian form. The inertia tensor and rigid bodies. Canonical transformations and Poisson brackets. Small oscillations. Additional topics as time allows; Hamilton-Jacobi theory, perturbation theory. PREREQUISITES: PH 3152, PH 2352 or equivalent.

**PH 4281 Electro-Optic Devices (4-0).**
Infrared, visible and ultraviolet detectors and their limitations; electron optical devices; scanning devices; image displays and storage techniques; starlight viewing devices; viewing devices for self-luminous infrared sources; optical tracking; lasers and applications; coherent optical information processing and holography; nonlinear optical devices; optical heterodyning; acoustic-optic devices; fiber and film optical devices; optical signal processing and switching. PREREQUISITES: PH 3280 and a corequisite course in solid state physics.

**PH 4283 Laser Physics (4-0).**
The physics of lasers and laser radiation. Topics will include: quantum and semi-classical oscillator model, gain; Gaussian beams, stable and unstable resonators; rate equations, output coupling, mode locking, short pulsing; specifics of solid state, and gas laser systems; semiconductor lasers; high energy lasers; amplifiers and laser systems for fusion research; laser-surface interaction air breakdown, LSC and LSD waves. PREREQUISITES: PH 3652 or equivalent; or consent of Instructor.

**PH 4353 Electromagnetism III (4-0).**
Classical radiation theory; retarded potentials, Lienard-Wiechert potentials, fields of a fast electron, angular distribution and frequency spectrum of radiation from an accelerated point charge. Cherenkov radiation, Hertz potentials and dipole radiation, and radiation from linear antennas. PREREQUISITES: PH 2352.

**PH 4363 Scattering of Electromagnetic Waves (4-0).**
In this last of the three course sequence in Electromagnetism (PH 2351, PH 2352, PH 4363) the topics of study are: scattering and absorption of waves by single particles, multiple scattering and radiation transport through medium of random scatterers, propagation and scattering of waves in a turbulent continuous medium. PREREQUISITES: PH 2352, MA 3132 or similar.

**PH 4371 Classical Electrodynamics (3-0).**
Tensors in special relativity. Classical relativistic electromagnetic field theory. Lorentz electron theory. PREREQUISITES: PH 4353 and familiarity with the special theory of relativity and Lagrangian mechanics.

**PH 4400 Advanced Acoustics Laboratory (0-6).**
Advanced laboratory projects in acoustics. PREREQUISITES: PH 3452 or equivalent.

**PH 4453 Radiation and Scattering of Waves in Fluids (4-0).**
An advanced treatment of special topics related to sound propagation in the ocean, including: multipole radiation fields, incoherence and

coherence; applications of the Helmholtz integral, probability density functions, correlations and frequency spectra of sound scattered from rough boundaries. PREREQUISITE: PH 3452 or consent of Instructor.

**PH 4454 Transducer Theory and Design (3-2).**
A treatment of the fundamental phenomena basic to the design of transducers for underwater sound and specific examples of their application. Topics include piezoelectric, magnetostrictive and hydromechanical effects. Laboratory experiments on measurement techniques, properties of transducer materials and characteristic of typical transducer types. PREREQUISITE: PH 3452.

**PH 4456 Seminar in Applications of Underwater Sound (3-0).**
A study of current literature on applications of acoustics to problems of Naval Interest. PREREQUISITE: PH 4453, or consent of Instructor.

**PH 4459 Shock Waves and High-Intensity Sound (3-0).**
A study of the physics of shock wave phenomena with emphasis on acoustics, such as sonic booms and underwater explosions; the development of the nonlinear acoustic wave equation and its application to intense sound propagation, such as the parametric generation and detection of sound; and selected topics in large amplitude sound of mutual interest to the students and the instructor.

**PH 4473 Advanced Topics in Underwater Acoustics (4-0).**
The last course in the acoustics sequence for students in the ASW curriculum, it is in part, a continuation of the preceding course, PH 3472. Topical content will vary somewhat depending upon the background and interests of the students, it shall include: Normal mode propagation in the ocean and transmission loss models in shallow water; Reflection from liquid-solid boundaries with an introduction to realistic models for bottom relfectivity target strength and an introduction to noise and vibration control aboard ships. Other topics may include current developments in Variability of target strength and of radiated noise, scattering from rough surfaces, Optimum frequencies for sonar, Coatings for reducing reflectivity and Parametric generation of sound. PREREQUISITE: PH 3472 or consent of the Instructor and SECRET clearance.

**PH 4571-4572 Statistical Physics I-II (3-0).**
Kinetic theory and the Boltzmann theorem, configuration and phase space, the Liouville theorem, ensemble, theory, microcanonical, canonical and grand canonical ensembles, quantum statistics. Applications to molecules, Bose-Einstein gases, Fermi-Dirac liquids, and irreversible processes. PREREQUISITES: PH 2152, 3651, 2551.

**PH 4630 Space Physics I: Physics of the Upper Atmosphere and the Geomagnetic Field (4-0).**
Description and origin of main geomagnetic field, temporal and spatial variations, properties of the ionosphere, radiation belts and solar wind. Magnetic storms. Experimental techniques and military applications. PREREQUISITE: PH 2352 or consent of the Instructor.

**PH 4631 Space Physics II — Introduction to Astrophysics (4-0).**
Introduction to theories of stellar interior, energy transport in stars, and stellar evolution. PREREQUISITE: Consent of Instructor.

**PH 4661 Plasma Physics I (4-0).**
This course constitutes a broad study of the behavior and properties of gaseous plasma, the fourth — and most abundent — state of matter in the universe. Plasma physics is a vigorously developing branch of contemporary physics. Its many applications are in areas such as astro- and space-physics, atomic physics, magneto-hydrodynamic power generation, electron beam excited laser, laser isotope enrichment, ionospheric communication, and themonuclear fusion. The physical concepts fundamental to various branches of plasma physics are introduced. Topics covered include single particle motions in electromagnetic fields, orbit theory, collision phenomena, breakdown in gases, and diffusion. The magnetohydrodynamic and the two-fluid plasma models are considered. PREREQUISITES: PH 2352, PH 3561, PH 3651, or the equivalent.

**PH 4662 Plasma Physics II (3-0).**
A continuation of Plasma Physics I. Applications of the hydromagnetic equations to the

study of macroscopic motions of plasma. Equilibrium and stability. Classification of plasma instabilities. Kinetic theory, the Boltzmann equation and the macroscopic momentum transport equation. Plasma oscillations and Landau damping. Nonlinear effects, shock waves, Radiations from plasma, including bremsstrahlung and cyclotron radiation. Controlled fusion and laser produced plasmas. PREREQUISITES: PH 4353, PH 4661 or equivalent.

**PH 4681 Advanced Plasma Physics (3-0).**
Selected topics in plasma physics, such as laser-target interaction, dynamics of a laser-produced plasma, self-generated magnetic fields, light scattering and absorption in plasma, turbulence and fluctuations, collisionless shock waves. PREREQUISITES: PH 4662 or consent of the Instructor.

**PH 4685 Advanced Atomic Physics (3-0).**
Selected topics in atomic spectroscopy and atomic collisions. Classical and quantum description of the collision process, transition probabilities and line broadening mechanisms. PREREQUISITES: PH 3651 and consent of the Instructor.

**PH 4750 Radiation Effects in Solids (4-2).**
Energy loss of radiations in matters, radiation dosimetry, energy transfer of radiation to matter, theory and spectra of radiation from nuclear weapons, fireball development, electromagnetic pulse phenomena, displacements of atoms in solids, radiation damage to solid-state devices. PREREQUISITE: PH 3652.

**PH 4760 Solid State Physics (4-2).**
Fundamental theory and related laboratory experiments dealing with solids: crystals, binding energy, lattice vibration, dislocations and mechanical properties, free electron theory, band theory, properties of semiconductors and insulators, magnetism. PREREQUISITES: PH 3651 or PH 3561 (the latter may be taken concurrently).

**PH 4790 Theory of Quantum Devices (3-0).**
Theory of the operation of electronic devices depending on energy states and the quantum nature of radiation; topics in quantum mechanics, spin resonance, rotating coordinates, relaxation times, amplifiers, magnetic instruments. PREREQUISITE: PH 2641 or PH 3651.

**PH 4851 Nuclear Physics (4-0).**
Nuclear decay schemes and energetics; nuclear forces; the deuteron and low energy nucleon-nucleon scattering; partial wave and analysis of scattering; neutron-induced reactions and the Breit-Wigner formula; beta and gamma Decay; and Q-value in reactions. PREREQUISITES: PH 3652, PH 3951 and PH 2352.

**PH 4881-4882 Advanced Nuclear Physics I-II (3-0).**
Relativistic mechanics, scattering of electrons from nuclei, nuclear models, nuclear potentials. Relativistic treatment of the electron using the Dirac equation and application to electron scattering to develop the Mott cross-section; treatment of form-factors arising from electron-nucleon and electron-nucleus scattering; application of electron scattering to study the structure of nucleon matter and the study of nucleon models. PREREQUISITE: PH 4851.

**PH 4885 Reactor Theory (3-0).**
The diffusion and slowing-down of neutrons. Homogeneous thermal reactors, time behavior; reactor control. Multigroup theory. Heterogeneous systems. PREREQUISITES: PH 2810 or equivalent; differential equations.

**PH 4900 Introduction to Experimental Research (0-3).**
This course is a continuation of PH 3900. Attention is normally concentrated upon instrumentation, techniques and analysis appropriate to the student's thesis. PREREQUISITE: Consent of Department Chairman. **Graded on Pass/Fail basis only.**

**PH 4971-4972-4973 Quantum Mechanics I-II-III (3-0).**
General principles of nonrelativistic quantum mechanics; stationary states. Addition of angular momenta; time-independent and time-dependent perturbation theory; scattering theory; identical particles and spin. General principles of relativistic quantum mechanics; properties and solutions of relativistic wave equations. PREREQUISITES: PH 3651, 4171.

**PH 4981-4982 Quantum Field Theory I-II (3-0).**
General principles of quantum field theory; quantization of scalar, spinor, and electromagnetic fields. Interacting fields; the S-matrix and renormalization; strong, electromagnetic,

and weak interactions; introduction to dispersion relations. PREREQUISITE: PH 4973.

**PH 4991 Relativity and Cosmology (3-0).**
Einstein's general theory of relativity. The three classical tests. The Schwarzschild singularity and black holes. Cosmological models and their relations with observations. Introduction to modern developments; gravitational waves, Dicke's theory, problems of quantum cosmology and superspace. PREREQUISITE: PH 4371.

**PH 4993 Physical Group Theory (3-0).**
Invariance of quantum mechanical systems to certain groups of transformations. Topics are selected from finite rotation groups and crystal symmetries, the continuous rotation group in three dimensions, transformation groups associated with elementary particle symmetries. PREREQUISITE: PH 4972.

**PH 4998 Special Topics in Advanced Physics (1-0 to 4-0).**
Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. It may also be taken on pass-fail basis if the student has requested so at the time of enrollment. PREREQUISITE: Consent of the Department Chairman.

## CHEMISTRY

*Lower Division Courses*

**CH 1001-1002 Introductory General Chemistry I-II (4-2) and (3-2).**
A two-quarter sequence for students who have not had college chemistry. A study of the principles which govern the physical and chemical behavior of matter. Practical applications of chemical principles.

*Upper Division Courses*

**CH 2001 General Principles of Chemistry (3-2).**
A study of the fundamental principles of chemistry governing the physical and chemical behavior of matter. Current theories of atomic structure and chemical bonding are particularly emphasized. Also studied are the states of matter and chemical equilibria. Special attention is given to the compounds of carbon. Elementary physical chemistry experiments are performed in the laboratory. PREREQUISITE: College chemistry.

**CH 2010 Inorganic Analysis (3-3).**
A continuation of CH 2001. Computations involving acid-base, solubility, and complex ion equilibria. Principles of quantitative analysis. Descriptive inorganic chemistry. Laboratory work will consist of gravimetric and volumetric analysis. PREREQUISITE: CH 2001 or CH 1002.

**CH 2102 Inorganic Chemistry (3-3).**
Redox reactions and the electrode potential. Introduction to reaction mechanism. Bonding in inorganic species. Acids and bases. Laboratory will make use of qualitative, semi-quantitative, and instrumental methods to study the principles further, especially as applied to the solution chemistry of the metals. PREREQUISITES: CH 2101 and CH 2402.

**CH 2201 Chemical Instruments (3-3).**
A course designed to familiarize the student with modern instrumental techniques of chemical analysis. Emphasis is given to the theoretical basis of the various kinds of measurements made in the laboratory and the principles involved in the design and construction of analytical instruments. Laboratory experiments will deal with representative analytical problems. PREREQUISITES: CH 2101 and CH 2403.

**CH 2301-2302 Organic Chemistry I-II (4-3) and (3-3).**
The chemistry of organic compounds. Emphasis in the laboratory on synthetic techniques.

**CH 2401 Chemical Thermodynamics (4-1).**
The laws of thermodynamics and their applications to chemical systems. Use is made of the chemical potential in describing multicomponent systems and the conditions for thermodynamic equilibrium. PREREQUISITE: Differential equations.

**CH 2402-2403 Physical Chemistry I-II (4-2) and (4-3).**
A continuation of the subject matter of CH 2401 covering chemical equilibrium and kinetics,

electrochemical cells, kinetic theory of gases and introductory atomic and molecular structure.

**CH 2910 Interaction of Naval Operations and Environmental Pollution (4-0).**
An interdisciplinary course which examines the impact of environmental pollution on Naval operations by examining current technical status, future plans for abatment, and the resultant limitations placed on Naval facilities, especially ships. The course will consider air, water, nuclear, and noise pollution or the potential for pollution as appropriate. PREREQUISITES: Math through college algebra. Two quarters of physical science or biology within the last two years is desirable.

*Upper Division or Graduate Courses*

**CH 3101 Advanced Inorganic Chemistry (3-3).**
Coordination compounds and crystal field theory. Inorganic reaction mechanisms. The laboratory introduces the student to general methods for investigating chemical reaction. PREREQUISITES: CH 2101, CH 2403.

**CH 3301 Physical Organic Chemistry (3-0).**
First quarter of two-quarter sequence. In this term the tools available for the study of organic mechanisms are discussed and apppropriate examples used. PREREQUISITES: CH 2302, CH 3101.

**CH 3402 Physical Chemistry in Ordnance Systems (4-2).**
A course in topics of special interest to students in Ordnance Engineering. Thermochemistry, chemical equilibrium, chemical kinetics, electrochemistry. Applications will include problems in explosives and propellants, corrosion, fuel cells, remote sensors, and environmental effects. The laboratory will amplify the lecture material especially through the use and study of chemical instruments. PREREQUISITES: PH 2551; a previous course in chemistry.

**CH 3403 Chemical Thermodynamics (3-0).**
Application of thermodynamics to ideal and to real gases, non-electrolyets, electrolytic solutions, multicomponent solutions. Calculations of equilibria, estimation of thermodynamic quantities and brief discussion of calculations of thermodynamic properties from spectroscopic and other molecular data. PREREQUISITES: Physical chemistry, elementary thermodynamics.

**CH 3405 Molecular Dynamics (5-0).**
Direct application of the Schroedinger wave equation to the hydrogen atom, angular momentum, matrix formulation of quantum mechanics, electro spin, the Pauli principle, interaction with electromagnetic radiation, development of group theory and application in quantum mechanics, and application of preceding framework to molecular hydridization, molecular orbital theory, ligand field theory, and vibrational spectra. PREREQUISITES: CH 2403, Matrix algebra.

**CH 3415 Statistical Mechanics (4-0).**
A general treatment of the principles of quantum and classical statistical mechanics with applications to chemical systems. Included are distribution laws and the relationships of Fermi-Dirac, Bose-Einstein, and corrected Boltzmann statistics, applications to chemical equilibria, diatomic and polyatomic molecules including ortho and para hydrogen; canonical and grand canonical ensembles; real gases. PREREQUISITES: CH 2403.

**CH 3761 Explosives Technology (4-0).**
Characteristics and terminology applied to explosives and propellants, manufacture and fabrication of explosives and explosive devices, detonics, thermochemical, and chemical kinetics of detonations. PREREQUISITES: PH 2551, CH 2402, and MS 2201 or equivalent.

**CH 3998 Special Topics in Intermediate Chemistry (1-0 to 4-0).**
Study in one of the fields of intermediate chemistry selected to meet special needs or interests of students. The course may be conducted as seminar or supervised reading and carries a letter grade. It may be repeated in different topics. It may also be taken on pass-fail basis if the student has requested so at the time of enrollment. PREREQUISITE: Consent of the Department Chairman.

*Graduate Courses*

**CH 4302 Physical Organic Chemistry II (3-0).**

The techniques discussed in CH 3301 are used in the study of organic reaction mechanisms as currently understood. PREREQUISITE: CH 3301.

**CH 4406 Quantum Chemistry (3-0).**
A study of molecular spectra and molecular electronic structure, emphasizing theory, interpretation, and prediction of spectra utilizing the quantum mechanical formulation. PREREQUISITE: CH 3405.

**CH 4410 Chemical Kinetics (3-0).**
Experimental methods and interpretations of data. Collision theory and activated-complex theory. Mechanisms of reactions. PREREQUISITES: CH 2403 and consent of Instructor.

**CH 4505 Radiation Chemistry (3-0).**
A study of the theory behind the chemical processes occurring when ionizing and electromagnetic radiation interact with matter. Includes electronic states of molecules, introduction to photochemistry, properties of gaseous ions and free radicals, chain reactions. PREREQUISITE: CH 2403 or the equivalent.

**CH 4998 Special Topics in Advanced Chemistry (1-0 to 4-0).**
Study in one of the fields of advanced chemistry or related applied areas selected to meet special needs or interest of students. The course may be conducted as seminar or supervised reading, carries a letter grade and may be repeated in different topics. It may also be taken on pass-fail basis if the student has requested so at the time of enrollment. PREREQUISITE: Consent of Department Chairman.

## OTHER COURSES

*SE 2001 through SE 4006 are a series of courses specifically designed for students in the Naval Intelligence Curriculum (825).*

### Upper Division Courses

**SE 2001 Environment, Wave Propagation and Ocean Systems (4-0).**
This is the first course of a five course sequence designed for the Naval Intelligence Curriculum to introduce the concepts of military technology. In this course, basic concepts of environmental science are reviewed and related to environmental data networks, environmental effects upon the propagation of acoustic and electromagnetic waves are studied, fundamentals of acoustic surveillance systems are developed, and current capabilities are discussed.

**SE 2002-2003 Concepts of Science and Engineering I-II (4-0).**
A two course sequence designed to prepare an advanced student with a non-quantitative and non-technical background for the study of advanced technology systems. Topics include: linear systems modeling and characteristics, spectral analysis, wave properties and wave phenomena, and computer systems; photography and photogrammetry, communication systems, signal processing, and control systems. PREREQUISITE: Mathematics including an introduction to differential and integral calculus.

**SE 2279 Directed Studies in Science and Engineering (Credit open).**
Independent study in science and engineering topics in which formal course work is not offered. PREREQUISITE: Permission of Department Chairman. *Graded on Pass/Fail basis only.* (Graduate students register for SE 3279).

### Upper Division or Graduate Courses

**SE 3004-3005 Survey of Military Technology: Concepts and Applications I-II (4-0).]**
A two course sequence designed to familiarize the student with the conceptual basis of military applications of technology. The first course treats communications systems, radar systems, electronic surveillance systems and electrooptics systems. The second treats strategic systems, satellite systems, missile systems, selected topics in aeronautical and naval engineering, and acoustic surveillance systems. PREREQUISITES: SE 2003, or equivalent, and SECRET clearance (NOFORN).

**SE 3279 Directed Studies in Science and Engineering (Credit open).** (See SE 2279). *Graded on Pass/Fail basis only.*

### Graduate Courses

**SE 4006 Special Topics in Technology Assess-**

ment (4-0).
Methods by which the technological capabilities of a nation, either current of future, will be assessed. Problems in source evaluation, cross-impact analysis, and trend extrapolation. Delphi studies and their role. As a part of their seminar, the student will make a detailed study and report on the methodology and results of a current technology assessment study. Content will vary, depending upon availability of material and the current interests of the professor and students. PREREQUISITES: SE 3004, SE 3005, and SECRET clearance (NOFORN).

SE 4064 Comparative Command, Control, Communications and Ocean Surveillance (3-0).
An examination of the command and organizational structures, control philosophies, communications systems and ocean surveillance systems of the Soviet and US Navis. The course begins with the Soviet approach which is used as a basis of comparison with the US approach. Possible exploitable features of the command and control structure are considered. The course emphasizes readings in the appropriate literature, research and seminar discussions. PREREQUISITES: NS 3420, TOP SECRET clearance with access to special intelligence information. SE 2003, OS 3207 or equivalent. *May also be taught as NS 4064.*

# DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

**Tyler Freeland Dedman,** Rear Admiral, U.S. Navy, Director: B.S., U.S. Naval Academy, 1947; B.S. in Aeronautical Engineering, Naval Postgraduate School, 1956; M.S. in Engineering, Princeton Univ., 1957.

**John Edward Dawson,** Professor; Executive Director (1966)*; B.A., The Principia College, 1953; M.P.A., Syracuse Univ., 1954; D.P.A., 1971.

**Sherman Wesley Blandin, Jr.,** Associate Professor; Assistant Director, Defense Activities (1968); B.S., U.S. Naval Academy, 1944; B.S., Georgia Institute of Technology, 1952; M.S., 1953; M.B.A., Univ. of Santa Clara, 1973; Ph.D., 1977.

**Edwin John Doran,** Adjunct Professor; Assistant Director, Academic Programs (1975); B.A., Univ. of Pennsylvania, 1955; M.S., Naval Postgraduate School, 1968; M.B.A., Univ. of Santa Clara, 1972; Ph.D., 1977.

**William Alan Mauer,** Professor, Assistant Director of Faculty Development and Research (1966); A.B., San Jose State College, 1955; M.S., Agricultural and Mechanical College of Texas, 1957; Ph. D., Duke Univ., 1960.

**Alexander Wolfgang Rilling,** Associate Professor; Assistant Director, International Activities (1974); B.S., Rensselaer Polytechnic Institute, 1951; M.S., Naval Postgraduate School, 1962; Ph.D., Univ. of Southern California, 1972.

**Robert Moffat Allan, Jr.,** Professor (1971); B.A., Stanford Univ., 1941; M.S., Univ. of California at Los Angeles, 1942.

**James Sherman Blandin,** Assistant Professor (1974); B.A., Univ. of California at Santa Barbara, 1968;M.B.A., Univ. of Oregon, 1972; Ph.D., 1974.

**Robert Edward Boynton,** Associate Professor (1970); B.A., Univ. of Minnesota, 1956; M.A., 1962; Ph.D., Stanford Univ., 1968.

**John Paul Brennan,** Lieutenant Commander, U.S. Navy; Assistant Professor (1974); B.S. Univ. of California at Berkeley, 1961; M.B.A., California Lutheran College, 1974.

**William Ayers Campbell,** Associate Professor (1970); B.S., Tuskegee Institute College, 1937; M.S.I.M., Univ. of Pittsburgh Graduate School, 1949.

**Frank Elmer Childs,** Professor (1965); B.A. Williamette Univ., 1934; M.B.A., Univ. of Southern California, 1936; Ph.D., Univ. of Minnesota, 1956.

**William Frederick Dunbar,** Major, U.S. Air Force; Instructor (1975); B.B.A., Univ. of Wisconsin, 1961; M.A., Southern Methodist Univ., 1973.

**Charles Joseph Forsman,** Commander, U.S. Navy; Instructor (1976); B.S. Naval Academy, 1958; M.S., George Washington Univ., 1967; M.S., Naval Postgraduate School, 1973.

**Peter Carl Frederiksen,** Assistant Professor (1974); B.A., Golden Gate College, 1967; M.A., San Francisco State College, 1969; Ph.D., Washington State Univ., 1974.

**Clyde Joseph Johnston,** Lieutenant Colonel, U.S. Marine Corps, Instructor (1976); B.S., Univ. of Colorado, 1959; M.B.A., Harvard Univ., 1970.

**Louis Henry Knipling, Jr.,** Colonel, U.S. Army; Assistant Professor (1976); B.S., Carnegie Tech, 1948; M.S. Ohio State Univ., 1956; Ph.D., 1973.

**Clifford Monson MacDonald, Jr.**, Major, U.S. Army; Instructor (1977); B.S., Worcester Polytechnic Institute, 1964; M.B.A., Drexel Univ., 1973.

**Norman Plotkin**, Assistant Professor (1969); B.S., Univ. of California at Los Angeles, 1948; B.F.S., Georgetown Univ., 1950; M.S., Claremont Graduate School, 1966; Ph.D., 1969.

**Richard Edward Saunders**, Commander, U.S. Navy; Assistant Professor (1977); B.S., Naval Postgraduate School, 1967; M.S., 1970.

**Robert von Pagenhardt**, Professor (1967); A.B., Stanford Univ., 1948; M.S., 1954: Ph.D., 1970.

**Gerald Allen Whitney**, Assistant Professor (1977); B.S., Nicholls State Univ., 1968; Ph.D., Tulane Univ., 1977.

**Richard Dana Young**, Assistant Professor (1977); B.A., Humboldt State College, 1969; Ph.C Univ. of California at Santa Barbara, 1973.

**The year of joining the Postgraduate School Faculty is indicated in parenthesis.*

## DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

The Navy Management Systems Center, a jointly staffed DoD sponsored activity, was established as a separate Naval Activity in February 1966. As of 1 July 1974 the name was changed to Defense Resources Management Education Center. It conducts both resident and on-site defense resource management courses for U.S. and international military personnel of all services in grades 0-4 and above and military-related civilians of equal grades. The focus of all programs conducted by the Center is on the development of knowledge and improvement of understanding of the concepts, techniques and application of modern defense management systems, with specific emphasis on effective resource management.

The Center currently offers a four-week U.S. Defense Management Systems Course eight times each year, a one-week Flag/General Defense Management Course twice each year, a thirteen-week Senior International Defense Management Course one time each year (similar to the 13-week international course but contracted). In addition to the DoD programs, the Center is currently involved in presenting management programs on-site to the service components and selected governments.

Since 1966, the Center has graduated over 10,000 students.

Faculty members of the Center are a part of the regular faculty of the Postgraduate School.

## DEFENSE MANAGEMENT SYSTEMS COURSE

The Planning-Programming-Budgeting System as developed since 1961 by the Office of the Secretary of Defense has provided a framework for examining various force mixes, allocation of resources, and relationships to military capabilities.

The objective of the 4-week De fense Management Systems Course is to provide an appreciation of the concepts, principles, and methods of defense management as they concern planning, programming, budgeting, and related activities. The course covers force planning, Department of Defense programming, program budgeting, and their interrelationships with resource management systems. Emphasis is placed on the analytical aspects of

management, steming from the disciplines of management decision theory, economics, and quantitative analysis.

Students are not expected to become experts or technicians in the various disciplines and subjects included in the curriculum. The objectives are to provide orientation on the overall functioning of the defense management process, insights as to what defense management requires in the way of inputs and analysis for decision-making, understanding of the principles, methods and techniques used, and awareness of the interfaces between management requirements of the Department of Defense components and the Office of the secretary of Defense. Course methodology includes lectures, small group discussions reinforced by illustrated case studies and problem sets, as well as selected daily reading assignments.

## FLAG/GENERAL DEFENSE MANAGEMENT COURSE

The Flag/General course is a one-week program of professional continuing education that is designed to improve understanding of the concepts, principles, methods and techniques drawn from the disciplines of management decision theory, economics and quantitative analysis. These ideas are integrated into a systematic framework for decision making. Applications include analysis and evaluation of defense systems, programs and polices and the allocation of scarce resources among programs. Course methodology includes lectures, small group discussions reinforced by illustrated case studies and problem sets, as well as selected daily reading assignments.

## INTERNATIONAL DEFENSE MANAGEMENT COURSE

The course is designed for participants in the military grades of 0-4 (Major/Lieutenant Commander) through 0-6 (Colonel/Captain) and defense-related civilians of equivalent rank. Enrollment is currently limited to a maximum of 50 participants. Broad national representation is desired for this course, i.e., participation by at least eight or ten nations enhances the value of the comparative management aspects of the curriculum.

The Course is presented in English.

The course provides a series of lectures in three major areas: environmental factors; quantitative and economic analysis; and management systems in the context of strategy, implementation, and operations. The lectures are supplemented by small group discussions and workshops which concentrate on the lecture topics and associated readings, problems, and cases. In the discussion groups, faculty members guide the interchange of ideas and are available to answer questions. Readings are assigned from within texts and supplemental material given to the participants to facilitate preparation for each lecture. Lecture outlines with additional suggested reading lists are provided. Occasional open seminar speakers are invited for special topics.

Early in the course, participants are requested to give brief presentations (by country) on their particular environmental situations, including such information as geographic factors, economic factors, social and cultural considerations, governmental and defense organizations, and unique management situ-

ations and/or problems. Throughout the course, the participants are encouraged to present and discuss information with respect to the defense management systems of their countries, and to examine how the management concepts and techniques discussed by both the Center faculty and the participants from other countries may be applied in their own situations. Comparative study by means of interaction among participants is considered to be an extremely valuable characteristic of the course.

During the course, the Center conducts field trips to selected military and commercial installations in the central California area. These trips provide an opportunity for the participants to receive special briefings on management techniques and problems, and to observe actual practices at the operating level.

In the second half of the course the general concepts of defense management are elaborated in detail during the examination of actual systems in financial, material and human resources management. At the end of the course a general review integrates the formal course material, special topics, and field trip experiences.

## SENIOR INTERNATIONAL DEFENSE MANAGEMENT COURSE

Enrollment is restricted to military flag and general officers (grades 0-7 and above) and defense-related civilians of equivalent rank, except that for countries where the 0-6 grade is comparable to flag/general rank such officials may be enrolled on a waiver basis. Participation in past courses has been as high as 45 individuals from as many as 18 countries; a maximum of 50 participants can be accommodated.

The Course is presented in English.

The lecture, small discussion group, environmental seminar, case study and problem format and content described above for IDMC also applies, but compressed in time. Two or three guest speakers are included and a field trip is conducted.

# DISTINGUISHED ALUMNI

Among those who have completed a Naval Postgraduate School curriculum who attained flag (USN) or general (USMC) rank on the active list are the following: (The asterisk [*] indicates those on active list as of 1 October 1977.)

Admiral Walter F. Boone
Admiral Arleigh A. Burke
Admiral Maurice E. Curts
Admiral Robert L. Dennison
Admiral Donald B. Duncan
Admiral Cato D. Glover, Jr.
Admiral Roscoe F. Good
Admiral Charles D. Griffin
Admiral Byron H. Hanlon
Admiral Ephraim P. Holmes
Admiral Frederick H. Michaelis*
Admiral Albert G. Noble
Admiral Alfred M. Pride
Admiral James C. Richardson
Admiral Hyman G. Rickover*
Admiral Horacio Rivero, Jr.
Admiral James S. Russell
Admiral Ulysses S. G. Sharp, Jr.
Admiral John H. Sides
Admiral Felix B. Stump
Admiral Alfred G. Ward
Admiral John M. Will
Vice Admiral Robert E. Adamson, Jr.
Vice Admiral Parker B. Armstrong*
Vice Admiral Frederick L. Ashworth
Vice Admiral Harold D. Baker
Vice Admiral Wallace M. Beakley
Vice Admiral George F. Beardsley
Vice Admiral Frank E. Beatty
Vice Admiral Fred G. Bennett
Vice Admiral Charles T. Booth, II
Vice Admiral Harold G. Bowen, Jr.
Vice Admiral John L. Boyes
Vice Admiral Carleton F. Bryant
Vice Admiral William M. Callaghan
Vice Admiral John H. Carson
Vice Admiral Ralph W. Christie
Vice Admiral John B. Colwell
Vice Admiral Thomas F. Connolly
Vice Admiral Glenn B. Davis
Vice Admiral Vincent P. Depoix
Vice Admiral Harold T. Deutermann
Vice Admiral Glynn R. Donaho
Vice Admiral Irving T. Duke
Vice Admiral Clarence E. Ekstrom
Vice Admiral Albert J. Fay
Vice Admiral Emmet P. Forrestel
Vice Admiral Laurence H. Frost
Vice Admiral William E. Gentner, Jr.
Vice Admiral Arthur R. Gralla
Vice Admiral Elton W. Grenfell
Vice Admiral Robert W. Hayler
Vice Admiral Truman J. Hedding
Vice Admiral Edwin B. Hooper*
Vice Admiral George F. Hussey, Jr.
Vice Admiral Thomas B. Inglis
Vice Admiral Andrew M. Jackson, Jr.
Vice Admiral Albert E. Jarrell
Lieutenant General Clayton C. Jerome
Vice Admiral Robert T.S. Keith
Vice Admiral Ingolf N. Kiland
Vice Admiral Jerome H. King, Jr.
Vice Admiral Harold O. Larson
Vice Admiral Kent L. Lee
Vice Admiral Ruthven E. Libby
Vice Admiral Vernon L. Lowrance
Vice Admiral William J. Marshall
Vice Admiral Charles B. Martell
Vice Admiral Kleber S. Masterson
Vice Admiral Ralph E. McShane
Vice Admiral Charles L. Melson
Vice Admiral Marion E. Murphy
Vice Admiral Lloyd M. Mustin
Vice Admiral Frank O'Beirne
Vice Admiral Francis P. Old
Vice Admiral Howard E. Orem
Vice Admiral Harvey E. Overesch
Vice Admiral Edward N. Parker
Vice Admiral Raymond E. Peet
Vice Admiral Forrest S. Petersen*
Vice Admiral Charles A Pownall
Vice Admiral Thomas C. Ragan
Vice Admiral Lawson P. Ramage
Vice Admiral William L. Rees
Vice Admiral Robert H. Rice
Vice Admiral Rufus E. Rose
Vice Admiral Richard W. Ruble
Vice Admiral Theodore D. Ruddock, Jr.
Vice Admiral Lorenzo S. Sabin, Jr.
Vice Admiral Harry Sanders
Vice Admiral Walter G. Schindler
Vice Admiral William A. Schoech
Vice Admiral Harry E. Sears
Vice Admiral Thomas G.W. Settle
Vice Admiral Wallace B. Short
Vice Admiral William R. Smedberg, III
Vice Admiral Chester C. Smith
Vice Admiral John V. Smith
Vice Admiral Roland N. Smoot
Lieutenant General Edward W. Snedeker
Vice Admiral Selden B. Spangler
Vice Admiral Thomas M. Stokes
Vice Admiral John Sylvester
Vice Admiral George C. Towner
Vice Admiral Robert L. Townsend
Vice Admiral Aurelius B. Vosseller
Vice Admiral Thomas J. Walker, III
Vice Admiral Edward C. Waller, III*
Vice Admiral James D. Watkins*

Vice Admiral Charles E. Weakley
Vice Admiral Charles Wellborn, Jr.
Vice Admiral Ralph Weymouth
Vice Admiral Ralph E. Wilson
Rear Admiral William C. Abhau
Rear Admiral Charles Adair
Rear Admiral John W. Ailes, III
Rear Admiral Herbert S. Ainsworth
Rear Admiral Frank Akers
Rear Admiral David M. Altwegg*
Rear Admiral John H. Alvis
Rear Admiral Charles C. Anderson
Rear Admiral Herbert H. Anderson
Rear Admiral Roy G. Anderson
Rear Admiral Willam L. Anderson
Rear Admiral Burton H. Andrews
Rear Admiral Erasmus W. Armentrout, Jr.
Rear Admiral Henry J. Armstrong
Rear Admiral Henry D. Arnold*
Major General George C. Axtell, Jr.
Rear Admiral Lee Baggett, Jr.*
Rear Admiral Watson O. Bailey
Rear Admiral William B. Bailey
Rear Admiral Fred E. Bakutis
Rear Admiral Nathaniel C. Barker
Rear Admiral Edwin Barrineau*
Rear Admiral Richard W. Bates
Rear Admiral Robert L. Baughan, Jr.
Rear Admiral Fred H. Baughman*
Rear Admiral John K. Beling
Rear Admiral David B. Bell
Rear Admiral Allan A. Bergner
Rear Admiral Philip A. Beshany
Rear Admiral Abel T. Bidwell
Rear Admiral Karl J. Bierderman
Major General Arthur F. Binney
Rear Admiral Horace V. Bird
Rear Admiral Worthington S. Bitler
Brigadier General Herbert J. Blaha
Rear Admiral Earnest Blake
Rear Admiral Calvin M. Bolster
Rear Admiral William A. Bowers
Rear Admiral Selman S. Bowling
Rear Admiral Frank A. Braisted
Rear Admiral Boynton L. Braun
Brigadier General George R. Brier
Rear Admiral Edward S. Briggs*
Rear Admiral Harold M. Briggs
Rear Admiral William A. Brockett
Rear Admiral Robert Brodie, Jr.
Rear Admiral Clarence Broussard
Rear Admiral Bert F. Brown
Rear Admiral Henry C. Bruton
Rear Admiral William C. Bryson
Rear Admiral Charles A. Buchanan
Rear Admiral William H. Buracker
Rear Admiral Raymond W. Burk
Rear Admiral Sherman E. Borroughs
Rear Admiral Jose M. Cabanillas
Rear Admiral William M. Callaghan, Jr.*
Rear Admiral Joseph W. Callahan
Rear Admiral Lucien Capone, Jr.*
Rear Admiral Robert W. Carius*
Rear Admiral Harold A. Carlisle
Rear Admiral Milton O. Carlson
Rear Admiral Albert S. Carter
Rear Admiral Edward W. Carter, III*
Rear Admiral Worrall R. Carter
Rear Admiral Gordon L. Caswell
Rear Admiral Charles J. Cater
Rear Admiral Robert W. Cavenagh
Rear Admiral Leonard C. Chamberlin
Rear Admiral Lawrence C. Chambers*
Rear Admiral Lester S. Chambers
Rear Admiral Lucius H. Chappell
Rear Admiral John D. Chase*
Rear Admiral Kenan C. Childers, Jr.
Rear Admiral William P. Chilton
REar Admiral Ernest E. Christensen
Rear Admiral Thomas J. Christman
Rear Admiral Karl J. Christoph
Rear Admiral Karl J. Christoph, Jr.*
Rear Admiral Albert H. Clancy, Jr.
Rear Admiral David H. Clark
Rear Admiral Henry G. Clark
Rear Admiral Jeane R. Clark
Rear Admiral Neal W. Clements*
Rear Admiral Leonidas D. Coates, Jr.
Rear Admiral Joe B. Cochran
Brigadier General Harold L. Coffman
Rear Admiral James E. Cohn
Rear Admiral Philip P. Cole
Rear Admiral William M. Cole
Rear Admiral Byran W. Compton, Jr.*
Rear Admiral Warren M. Cone
Rear Admiral Robert C. Conolly, II*
Rear Admiral Murray C. Cook*
Rear Admiral Samual M. Cooley, Jr.
Rear Admiral Joshua W. Cooper
Rear Admiral Frank W. Corley, Jr.
Rear Admiral John T. Corwin
Rear Admiral John T. Coughlin*
Rear Admiral Stanley T. Counts*
Rear Admiral Roy T. Cowdrey
Rear Admiral Donald V. Cox
Rear Admiral Richard S. Craighill
Rear Admiral John S. Crenshaw
Rear Admiral Samuel H. Crittenden, Jr.
Rear Admiral Robert E. Cronin
Rear Admiral Gordon J. Crosby
Rear Admiral John E. Dacey
Rear Admiral Anthony L. Danis
Rear Admiral James A. Dare
Rear Admiral Lawrence R. Daspit
Rear Admiral Cabell S. Davis, Jr.*
Rear Admiral Henry J. Davis, Jr.*
Rear Admiral James W. Davis
Rear Admiral John B. Davis, Jr.
Rear Admiral Ranson K. Davis
Rear Admiral Kenneth V. Dawson

Rear Admiral Dwight H. Day
Rear Admiral George H. Debaun
Rear Admiral Tyler F. Dedman*
Rear Admiral Walter Dedrick
Rear Admiral Ernest W. Dobie, Jr.
Rear Admiral Frank R. Dodge
Rear Admiral Joseph E. Dodson
Rear Admiral Oscar H. Dodson
Rear Admiral Marshall E. Dornin
Rear Admiral Jack S. Dorsey
Rear Admiral Wallace R. Dowd, Jr.
Rear Admiral Willard M. Downes
Rear Admiral Clayton R. Dudley
Rear Admiral Clifford H. Duerfeldt
Rear Admiral Robert F. Dunn*
Rear Admiral Crawford A. Easterling*
Rear Admiral Henry E. Eccles
Rear Admiral Edward H. Eckelmeyer, Jr.
Rear Admiral Claude P. Ekas, Jr.*
Rear Admiral Donald T. Eller
Rear Admiral Robert B. Ellis
Rear Admiral Paul H. Engel*
Rear Admiral Gordon S. Everett
Rear Admiral Marvin P. Evenson
Rear Admiral Delmer S. Fahrney
Rear Admiral Edward J. Fahy
Rear Admiral James M. Farrin, Jr.
Rear Admiral Emerson E. Fawkes
Rear Admiral James M. Fernald
Rear Admiral William E. Ferrall
Rear Admiral Clifford A. Fines
Rear Admiral Lee W. Fisher*
Rear Admiral Francis J. Fitzpatrick
Rear Admiral Morton K. Fleming, Jr.
Rear Admiral William B. Fletcher, Jr.
Rear Admiral William O. Floyd
Rear Admiral Eugene B. Fluckey
Rear Admiral Thomas J. Flynn
Rear Admiral Robert J. Foley
Rear Admiral Edward C. Forsyth
Rear Admiral James H. Foxgrover*
Rear Admiral John E. Fradd
Rear Admiral George K. Fraser
Rear Admiral Frederick R. Furth
Rear Admiral Walter D. Gaddis
Rear Admiral Daniel V. Gallery
Rear Admiral Robert K. Geiger*
Rear Admiral Paul C. Gibbons, Jr.*
Rear Admiral Donald T. Giles
Rear Admiral Fillmore B. Gilkeson
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Rear Admiral Robert O. Glover
Rear Admiral William B. Goggins
Rear Admiral Robert B. Goldman
Rear Admiral Alexander S. Goodfellow, Jr.
Rear Admiral Willard K. Goodney
Rear Admiral Roy W.M. Graham
Rear Admiral Etheridge Grant
Rear Admiral Alfred M. Granum
Rear Admiral Norman K. Green*
Rear Admiral Orville F. Gregor
Rear Admiral Bradford E. Grow
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Rear Admiral Stanley M. Haight
Rear Admiral Hamilton Hains
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Rear Admiral Harold S. Harnly
Rear Admiral William L. Harris, Jr.*
Rear Admiral Lloyd Harrison
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Rear Admiral William L. Hinkle*
Rear Admiral Charles M.E. Hoffman
Rear Admiral Carleton C. Hoffner
Rear Admiral James H. Hogg
Rear Admiral James B. Hogle
Rear Admiral M. Staser Holcomb*
Rear Admiral George A. Holderness, Jr.
Rear Admiral Paul A. Holmberg
Rear Admiral Carl C. Holmquist
Rear Admiral Leroy V. Honsinger
Rear Admiral Lewis A. Hopkins
Rear Admiral Charles F. Horne, Jr.
Rear Admiral Martin P. Hottel
Rear Admiral Herbert S. Howard
Rear Admiral Hamilton W. Howe
Rear Admiral Miles H. Hubbard
Rear Admiral Lester J. Hudson
Rear Admiral Harry Hull
Rear Admiral Harry R. Hummer, Jr.
Rear Admiral George P. Hunter
Rear Admiral William D. Irvin
Rear Admiral Joseph A. Jaap
Major General Samuel S. Jack
Rear Admiral David H. Jackson
Rear Admiral Jack M. James
Rear Admiral Ralph K. James
Rear Admiral Joseph F. Jelley, Jr.

Rear Admiral George E. Jessen*
Rear Admiral Frank L. Johnson
Rear Admiral Harry D. Johnston
Rear Admiral Horace B. Jones
Rear Admiral Allen R. Joyce
Rear Admiral William W. Juvenal
Rear Admiral Benjamin Katz
Rear Admiral Bruce Keener, III*
Rear Admiral Thomas J. Kelly
Rear Admiral John D. Kelsey
Rear Admiral Cecil J. Kempf*
Rear Admiral Marvin G. Kennedy
Rear Admiral John S. Kern
Rear Admiral Thomas J. Kilcline*
Rear Admiral Thomas S. King, Jr.
Rear Admiral Robert E. Kirksey*
Rear Admiral Thomas B. Klakring
Rear Admiral William M. Klee
Rear Admiral Arthur K. Knoizen*
Rear Admiral Denys W. Knoll
Rear Admiral Theodore H. Kobey
Rear Admiral Leland S. Kollmorgan*
Rear Admiral Edgar P. Kranzfelder
Rear Admiral William E. Kuntz
Rear Admiral Thomas R. Kurtz, Jr.
Rear Admiral David Lambert
Major General Frank H. Lamson-Scribner
Rear Admiral George A. Lange
Rear Admiral Richard A. Larkin
Rear Admiral Robert E. Laub
Rear Admiral Paul A. Lautermilch, Jr.*
Rear Admiral Martin J. Lawrence
Rear Admiral Frank C. Layne
Rear Admiral William H. Leahy
Rear Admiral Paul F. Lee
Rear Admiral Wilson D. Leggett, Jr.
Rear Admiral William E. Lemos
Rear Admiral John C. Lester
Rear Admiral Joseph S. Lillard
Rear Admiral Isham W. Linder
Rear Admiral Orlin L. Livdahl
Rear Admiral William H. Livingston
Rear Admiral Theodore C. Lonnquest
Rear Admiral Almon E. Loomis
Rear Admiral Wayne R. Loud
Rear Admiral Charles H. Lyman, III
Rear Admiral Duncan C. MacMillan
Rear Admiral Charles J. Maguire
Rear Admiral Joseph B. Maher
Rear Admiral Robert C. Mandeville, Jr.*
Rear Admiral Francis F. Manganaro*
Rear Admiral Harry C. Mason
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*June 1978 Graduation*

# POSTGRADUATE SCHOOL STATISTICS GRADUATES BY YEARS

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY YEARS

| | 1946-1950 | 1951-1955 | 1956-1960 | 1961-1965 | 1966-1970 | 1971-1975 | 1976 | 1977 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Bachelor of Arts | .... | .... | .... | 180 | 389 | 349 | 1 | .... | 919 |
| B.S. in Aeronautical Engineering | 73 | 212 | 212 | 181 | 61 | 15 | .... | .... | 754 |
| B.S. in Chemistry | .... | .... | 3 | 3 | 4 | 9 | .... | .... | 19 |
| B.S. in Engineering Acoustics | .... | .... | .... | .... | .... | 3 | 3 | 1 | 7 |
| B.S. in Electrical Engineering | 156 | 292 | 232 | 520 | 308 | 186 | 14 | 22 | 1,730 |
| B.S. in Engineering Science | .... | .... | .... | .... | 141 | 135 | .... | .... | 276 |
| B.S. in Environmental Science | .... | .... | .... | 12 | .... | .... | .... | .... | 12 |
| B.S. in Management | .... | .... | .... | 53 | 1 | .... | .... | .... | 54 |
| B.S. in Mechanical Engineering | 43 | 116 | 52 | 82 | 53 | 26 | 5 | .... | 377 |
| B.S. in Meteorology | 16 | 104 | 77 | 108 | 49 | 29 | .... | .... | 383 |
| B.S. in Operations Research | .... | .... | .... | .... | 49 | 63 | 5 | 2 | 119 |
| B.S. in Physics | .... | 15 | 36 | 75 | 35 | 19 | 2 | .... | 182 |
| B.S. in Systems Technology | .... | .... | .... | .... | .... | .... | 4 | 2 | 6 |
| Bachelor of Science | .... | 56 | 94 | 583 | 259 | 210 | 4 | 3 | 1,209 |
| Total Baccalaureate Degrees | 288 | 795 | 706 | 1,797 | 1,349 | 1,044 | 38 | 30 | 6,047 |
| M.A. in National Security Affairs | .... | .... | .... | .... | .... | 23 | 33 | 37 | 93 |
| M.S. in Aeronautical Engineering | .... | .... | .... | 40 | 115 | 224 | 50 | 38 | 467 |
| M.S. in Applied Science | .... | .... | .... | .... | .... | .... | 12 | 11 | 23 |
| M.S. in Chemistry | .... | .... | 16 | 5 | 32 | 16 | .... | .... | 69 |
| M.S. in Computer Science | .... | .... | .... | .... | 34 | 139 | 30 | 46 | 249 |
| M.S. in Computer Systems Management | .... | .... | .... | 22 | 247 | 294 | 38 | 34 | 635 |
| M.S. in Electrical Engineering | 75 | 154 | 124 | 190 | 318 | 345 | 62 | 60 | 1,328 |
| M.S. in Engineering Acoustics | .... | .... | .... | .... | 13 | 37 | 11 | 6 | 67 |
| M.S. in Management | .... | .... | .... | 406 | 633 | 964 | 137 | 142 | 2,282 |
| M.S. in Material Science | .... | .... | .... | 5 | 9 | .... | .... | .... | 14 |
| M.S. in Mechanical Engineering | 20 | 36 | 48 | 49 | 99 | 132 | 23 | 28 | 435 |
| M.S. in Meteorology | 23 | 19 | 40 | 53 | 53 | 126 | 7 | 13 | 334 |
| M.S. in Oceanography | .... | .... | .... | .... | 119 | 179 | 17 | 15 | 330 |
| M.S. in Meteorology and Oceanography | .... | .... | .... | .... | .... | .... | 4 | 11 | 15 |
| M.S. in Operations Research | .... | .... | .... | 63 | 305 | 549 | 67 | 54 | 1,038 |
| M.S. in Physics | .... | 25 | 104 | 135 | 124 | 102 | 16 | 11 | 517 |
| M.S. in Systems Technology | .... | .... | .... | .... | .... | 19 | 26 | 19 | 64 |
| M.S. in Telecommunications Systems Management | .... | .... | .... | .... | .... | .... | .... | 2 | 2 |
| Master of Science | .... | 17 | 65 | 102 | 56 | 25 | 1 | 1 | 267 |
| Total Master's Degrees | 118 | 251 | 397 | 1,070 | 2,157 | 3,174 | 534 | 528 | 8,229 |
| Aeronautical Engineer | .... | .... | .... | 4 | 33 | 45 | 4 | 2 | 88 |
| Electrical Engineer | .... | .... | .... | .... | 40 | 64 | 9 | 7 | 120 |
| Mechanical Engineer | .... | .... | .... | .... | 6 | 25 | 5 | 11 | 47 |
| Doctor of Philosophy | .... | .... | 1 | 14 | 25 | 38 | 6 | 6 | 90 |
| Doctor of Engineering | .... | .... | .... | .... | .... | .... | .... | 1 | 1 |
| Total Degrees | 406 | 1,046 | 1,104 | 2,885 | 3,610 | 4,390 | 596 | 585 | 14,622 |

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## — NOTES —

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